INTERNATIONAL DATA SPACES ASSOCIATION

Anthology | Version 1.0 | October 2021

Data Move People – Mobility Data Spaces

Publisher

International Data Spaces Association
Anna-Louisa-Karsch-Str. 2
10178 Berlin Germany

Editors

Christoph Schlueter Langdon
Deutsche Telekom

Christoph Mertens
International Data Spaces Association

Contributors

Harrie Bastiaansen, TNO
Stefan Bratzel, CAM
Holger Drees, BASt
Dennis Groot, KPN
Ruud Mollema, ICTU
Sebastian Pretzsch, Fraunhofer IVI
Lutz Rittershaus, BASt
Juergen Thoemmes, FHDW
Anant Vikram, T-Systems

Foreword

Mobility today is in a state of transition. Twentieth century modes and concepts of transportation have outlived their usefulness but are still largely in place.

This challenge is nowhere as visible as in our cities. Despite efforts to promote the use of alternative forms of transportation, cities are still organized around individual automotive travel. Yet moving around cities by car individually has become unsustainably inefficient in addition to reducing the quality of life in urban environments and costing an unacceptable number of lives.

What is required today is a radical rethinking of mobility. Travel in the 21st century needs to become smarter and more flexible. And the key this mobility revolution is the intelligent use of data.

This is nowhere as apparent as in the automobile industry itself. To meet the challenge of technological and societal challenges, it needs to drastically change it's business model. With the replacement of the combustion engine by the electrical engine, the decline of car ownership among young urban consumers and the rise of autonomous driving, the industry has to adjust to a massive market transformation.

One of the adjustments the industry is making is the reconceptualization of what it's product actually is. Instead of selling units, car makers are beginning to think of themselves as providers of mobility services. Instead of selling cars, automakers of the future will sell trips. This, however, requires a close collaboration with other mobility and infrastructure providers as well as a profound understanding of the rapidly changing transportation habits.

This new way of looking at mobility by the auto industry is completely in line with the most immediate solution to today's mobility problems of cities: Intermodal transportation. The most convenient, safest and quickest way to get around our cities today is to no longer rely on one mode of transportation but to combine the various available modes in a way that meets exact individual needs at any given time.

In many cities around the world, particularly young people have adopted intermodal transportation. Yet for intermodal travel to become the dominant form of mobility it has a long way to go to be sufficiently accessible and convenient.

The key to this transportation revolution again is data. To quickly and easily plan a trip that suits his or her individual needs, the consumer needs to have access to a wealth of data packaged to deliver the precise information he or she needs.

In the future consumers will be able to plan trips with their smart phone within seconds. The software will tell them how to combine electrical and mechanical ride share solutions with public transportation, car share options and even autonomous vehicles to achieve the exact transportation result desired.

The combined vision of intermodal travel and mobility as a service has the potential to solve the transportation problems of the 21st century within our cities as well as for long distance travel. The vision, however, requires the collaboration of all players: car manufacturers, transportation-sharing providers, rental companies, public transportation operators as well as governments. All these players need to be able to trust each other to cooperate in good faith toward a common goal.

A major obstacle to this is the reluctance especially of commercial players to share data. Luckily there are solutions available. Initiatives such as the "International Data Spaces" supported by various European governments and the European Union allow for a rule-based sharing of data that secures data sovereignty for each participant.

First implementations are already available, such as the IDS-based Trusted Connector of the Deutsche Telekom Data Intelligence Hub. Currently it is being used in the first laboratory of the National Platform Future of Mobility (NPM) until the end of 2021 in Hamburg. In this pilot project public transportation, a car rental company and a car share provider share data and provide consumers with customized transportation solutions.

European partners, meanwhile, are exploring regional, cross-border data sharing solution to improve transportation efficiencies and find new mobility solutions. The Dutch government for example is collaborating with Germany and other Benelux countries to create an international MaaS (mobility as service) alliance.

With the following papers we wish to explore in depth how data sharing can transform the future of mobility. We will document the manifest advantages of intermodal transportation and the idea of mobility as a service and explore the ways in which these advantages can made available to consumers and providers alike. We will lay out the rethinking that is necessary in order to revolutionize transportation and adapt it to the challenges of our time. And we will discuss the path to implementing a smart system of transportation throughout Europe and the world using data to the advantage of all players and the common good.

October 2021

Reinhold E. Achatz
Chairman of the Board
International Data Spaces Association

Table of Content

1 Mobility transformation and competitiveness of European automakers

Stefan Bratzel, Juergen Thoemmes, Christoph Schlueter Langdon

Mobility in general and the car in particular is in for a big change possibly more radical than anything since Henry Ford industrialized the business in 1913 by introducing the moving assembly line and mass-producing the Ford Model T. While Swabian Gottlieb Daimler invented the car with his 1886 patent for a riding car with a gas or petroleum engine, it was Ford who invented the modern business to create an affordable car for the mass market. Today, the automotive industry is facing challenges in three areas: technology, society, and economics or business model.

- First there is technology change. On the one hand there are industry-specific technology changes, specifically, two: electrification and autonomous driving. On the other hand, there is digitization in general, the "Internet" and Web and cloud computing, all of which have already transformed other industries, for example the media and entertainment industry. Examples include music, print media – think MP3 players, the early online services, such as America Online, and today's mobile social media (Schlueter Langdon & Bau 2007a, 2007b; Schlueter Langdon & Shaw 2003, 1997). In the traditional automotive industry, this digitization has previously fallen into the categories of "connected car," telematics, online sales, etc.
- Second, trends in society, such as urbanization, climate protection, and social media are reshaping society's values and attitude toward the car. More and more critical questions are being raised by both the public and politicians about the ecological impact of car traffic and its contribution to climate change. The Paris Climate Agreement, for instance, is calling for virtually full decarbonization of the transport sector in Germany by 2050. Also, the concept of car ownership seems to be fading a bit, particularly in densely populated urban areas, further diminishing the importance of selling cars to consumers.
- Third, these technological and societal changes are undermining the business model of the automotive industry. A key aspect here is the shift from selling hardware to offering services (see Figure 1, adapted from Schlueter Langdon 2019), with the focus already shifting toward various forms of auto-mobility, such as car-sharing or ride-hailing or multimodal smartphone-based transport services.

As a result, the traditional automotive industry with its original equipment manufacturers (OEMs) and tiered supplier pyramid is under pressure to change, on multiple fronts. This is even more so the case as new players – from newcomers like Tesla and Uber to internet giants like Apple and Google with potentially disruptive business models – have thrown down the gauntlet to established car manufacturers, threatening what is one of the most important industry sectors in Europe. Jim Farley, Ford's CEO and former head of the OEM's European operations, puts it bluntly: "We know our competition today is Amazon, Baidu, Tesla, Apple, Toyota, and others [...]. They're well-financed and voracious companies" (Naughton 2020).

One thing is for sure: The mobility transformation (or "Verkehrswende" in Germany) that is about to happen requires the industry and its stakeholders to show utmost willingness to change and it requires the capacity for innovation. Furthermore, infrastructure matters, which can be divided into material, immaterial, and institutional elements. Material infrastructure is about the technical and structural conditions, such as EV charging stations. Immaterial infrastructure includes the availability of human talent and skills, such as battery chemistry experts. Institutional infrastructure encompasses regulatory frameworks such as laws or standards that impact or enable the way in which data is processed, for example (see for example, Europe's General Data Protection Regulation, GDPR, link).

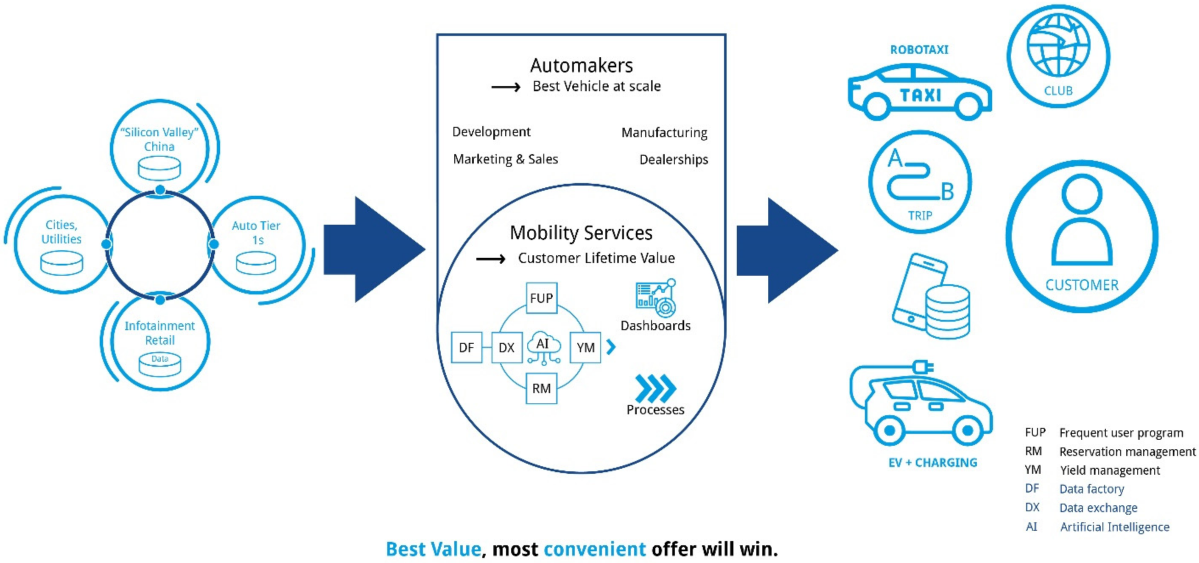

Figure 1: From making hardware to automating and selling services

1.1 Transformation

For many decades, cars and ever-increasing road traffic have dominated mobility in western industrial societies. The prosperity and economic development of a globalized and internationally collaborative world are closely related to the increase in private motorized transport and motorized freight services. Emerging economic powers like China have also adopted this western model, and their growing economic output is accompanied by a sharp rise in traffic and transport and increasing rates of motorization.

Today, it has become apparent that the growth in traffic volumes has negative health and environmental effects and consequences. Car traffic, in particular, is responsible for fatal accidents and causes damage to the environment in the form of air pollution, noise pollution, urban sprawl, and land use – despite some remarkable improvements achieved by safety and environmental technologies and measures.

1.1.1 Erosion of assumptions

So far, the whole business model of car manufacturers has been based on three core tenants – and all of them are called into question at almost the same time:

- The complex mass production of the internal combustion engine and its chassis is at the heart of value creation and a formidable entry barrier.
- Most consumers love cars and want to buy and own them.
- Cars need to be driven manually by a qualified driver.

These three pillars are eroding in the face of technological innovation, and socio-cultural and political changes. Firstly, the electric engine could replace the internal combustion engine as the dominant powertrain technology within the next 20 years, driven not only by the climate policy targets, but also by important key markets like China, which are forging ahead with e-mobility for industrial policy reasons.

Secondly, people are less and less inclined to buy and own cars, especially in densely populated urban areas, and among the younger generation. Cars remain a status symbol but seemingly for fewer. Instead, alternative forms of transportation such as car-sharing and e-bikes have become cool, practical and more popular (see Bratzel 2014).

Thirdly, there may not be a need for a qualified driver or chauffeur in the future when – as trial projects and visions of the future suggest – “robo-cabs” and “robo-buses” will do the driving for us. Various car manufacturers and new entrants like Uber are planning to launch their first fully autonomous series cars as early as 2025.

1.1.2 Opportunities

The erosion of the automotive industry’s foundations is profound, and the developments outlined above provide us with starting points to outline future paths. All three “follow the money” or economics so to speak, as they are based on extracting more value from an existing setup primarily through use of digital tools, such as data and analytics:

- Efficiency gains: Cars are idle 95 percent of the time. And even in the five percent of actual usage time only around 33 percent of the cars' full capacity are used in this country. Looking at it from the other end: There is lots of underutilized capacity available most of which is already paid for. What is more, cars are burning finite fossil fuels at a relatively low rate of efficiency and with negative effects on the environment and the climate. Many new business models and innovations are essentially addressing these inefficiencies: Digital transport service portals promise higher utilization of cars/taxis; sharing schemes enable otherwise unused "vehicle hardware" to be shared, and, running on renewable energy, electric cars can achieve high rates of efficiency while keeping external environmental costs low.

- Time savings: According to a study by the French car manufacturer Citroën, Europeans are spending an average of four years and one month of their lives in a car (Citroën 2016). All of this time is fully taken up by the task of driving and only very few other activities can be carried out simultaneously. As cars no longer need drivers, thanks to the autonomous driving functions of robo-cabs, the time we spend in cars can be used differently with a whole range of attractive new services. Areas where such personalized services could conceivably be offered include business, information, entertainment, wellness, or even consumer products.
- Customer fit: Henry Ford famously offered any customer to "have any car painted any color that he wants so long as it is black" (Henry Ford 1922). Similarly, people's transportation used to be very unimodal. To realize their mobility needs, people mostly relied on one dominant form of transport – primarily the private car. Alternative mobility options, or information about their availability, were hard to find. The last few years have not only been marked by the emergence of new mobility services (car-sharing, ridesharing, etc.). Thanks to internet-enabled smartphones with their geolocation (GPS) function, route planning has also become more and more effective, with mobility portals scanning all available transport modes and showing the fastest and most cost-efficient option. With information even more interconnected in the future, software systems will be able to check in real time the availability of transport modes and handle the billing process. The current unimodal pattern of people's transport behavior is transforming into a multimodal and intermodal or mobility pattern.

1.1.3 Accelerated competition and innovation

The shifts and jockeying for position to secure new opportunities has become very visible. For one, digital players have entered the field. This includes big established companies that are expanding from a strong digital business into mobility like Apple, Google, Amazon, Alibaba, or Baidu, but also newcomers like Uber or Didi Chuxing plus other players such as Deutsche Bahn and other transport companies. For another, incumbents have shifted and accelerated investments in electrification, autonomous driving, connectivity, and mobility services:

- The 20 global automotive groups representing approx. 80 brands have tripled their number of innovations over the past ten years from around 400 to 1,200 new products/services (Bratzel & Tellermann 2017, p. 29).
- At the same time, a seismic shift in the focus of innovation has taken place toward the technology fields of connectivity, interfaces, and advanced driver-assistance systems/autonomous driving, which now account for more than 50 percent of all innovations by car manufacturers, compared with just 33 percent in 2006 (CAM 2017, p. 4).
- There has also been a significant strategy rethink about engines among automakers in the last few years, with research and development funds being increasingly redirected toward e-mobility.

While these strategy fields are each in their own way significantly changing auto-mobility, the real game changer is that these trends are all appearing concurrently with interactions that could enable big leaps in consumer benefits: For example, an electric vehicle that is fully autonomous and can drive independently to inductive charging stations, is connected to the customers' demand for mobility, and can be ordered – as an on-demand service – as a robo-cab and be shared for the ride.

11 MAIN TYPES	~50 SERVICE TYPES
Car Sharing	Free-Float Carsharing, Peer-to-Peer Carsharing, etc.
Charging Services	
Data Services	Hazard Data, Traffic Data, etc.
Infotainment	Office & Messaging Entertainment, Local Information, etc .
Driving Agency	Private Taxi, Ride Sharing, etc.
Intermodale Services	
Logistic Services	Logistics, Marketplace, Temporary Key, etc.
Parking Services	Parking Payment System, Parking Finder (off the road), etc.
Renting	
Remote-Services	Emergency Call Service, Software-Car-Update, Car-Finder, etc.
Others	

~100 ACTORS

19 globale OEM

- BMW
- Daimler
- Fiat-Chrysler
- Ford
- Honda
- Hyundai
- Geely
- GM
- Mazda
- Mitsubishi
- Nissan
- PSA
- Renault
- Subaru
- Suzuki
- Tata
- Tesla
- Toyota
- VW

20 non-globale/Chinese OEM

- BYD
- Chery
- Mahindra
- Aston Martin
- etc.

10 Big-Data-Player

- Google
- Apple
- Baidu
- Samsung
- Alibaba
- Amazon
- Facebook
- Microsoft
- Huawei
- Tencent

49 Mobility-Player

- Uber
- Deutsche Bahn
- Didi Chuxing
- Sixt
- Avis Budget
- Enterprise
- Gett
- Moovit
- etc.

~500 INDIVIDUAL SERVICES

- Car2go
- UberPop
- UberBlack
- Koolicar
- ParkNow
- DriveNow
- Moovel
- Lyft Premier
- Flince
- Tesla Supercharger
- Mercedes-Benz- Rent
- Maven
- Audi Shared Fleet
- Apple CarPlay
- Haha Pinche
- MyBoxMan
- nuTonomy
- Free2move
- Book N Drive
- Cambio
- Greenwheels
- Fluidtime
- Moovit
- Moia
- Grab
- BVG Berlkönig
- Clevershuttle
- Call a bike
- FordPass
- Parkpocket
- Find My Car
- Taxify
- BlaBlaCar
- BMW Connected
- Drive
- Volkswagen Car Net
- OnStar
- Waymo
- etc.

Figure 2: Mobility service types, actors and examples (Bratzel & Thoemmes 2018, Fig. 7, p. 51)

1.1 Servitization

Mobility services are already a central business area of the future for digital players like Google, for newcomers like Uber, and equally for cities and municipalities. The vision of "Mobility as a Service" (MaaS) describes the vision of a seamless, highly interconnected travel and mobility chain across different transport modes – from intermodal route planning to booking on demand and payment, and through to handling the actual journeys (see Deloitte 2017b, p. 114). Other services, such as car parking services (such as Deutsche Telekom's Park and Joy), charging services, or entertainment services, can be added to this as well (see Fig. 2 for an overview). From the customer's perspective, the new mobility offerings such as car-sharing, bike- and ridesharing mean more mobility options and greater choice. Where, until recently, the approach to transport was predominantly unimodal, with all journeys either undertaken by private car or by public transport, the mobility pattern emerging in the times of internet-enabled smartphones is a multimodal or even intermodal one. This means customers can quickly satisfy their transport needs to suit their individual situation with a broad range of mobility offers at their fingertips enabling them to choose the most cost-effective, fastest, or most comfortable combination of means of transport. In the future, multimodal apps such as Moovel, Qixxit, UbiGo, or Whim will allow people to simply and securely plan, book, and sometimes even pay for the entire travel chain via smartphone in real time. The long-term goal is interoperability, i.e., the seamless overview, availability, and bookability as an optimized and customized mix of all mobility offerings – public transport, taxi, car-sharing, ride-hailing, and ridesharing, hire car or bike- sharing, etc. – for urban mobility (see MaaS Alliance 2017, p. 1, p. 5).

1.1.4 Efficiency, time and fit

Mobility services or MaaS are the foundation of new business models based on higher efficiency, time savings, and the orchestration of end-to-end service solutions with a better market fit. For automakers, mobility services combined with autonomous driving could provide the opportunity to tap into new business areas as an alternative to the previous commercial pillars, whose main focus of selling/owning cars and the joy of driving manually has set them on a downward trend (Holmberg et al. 2016, p. 14). At the same time, however, competition is growing, with digital players like Apple, Google, or Alibaba and Baidu entering the scene who are keen to expand their ecosystems of communications and entertainment services by adding mobility services to the mix. What is more, newcomers like Uber, Didi Chuxing, BlaBlaCar, and others are also muscling in with innovative digital mobility-on-demand services.

Not to forget the e-mobility and autonomous vehicle or robo-cab trends outlined above, which will enable even more innovative and cost-efficient mobility offerings. These will not only broaden the spectrum of mobility services, but also result in a fusion of public and private transport because the autonomous vehicle can generally be used both privately and as a taxi, car-sharing-vehicle or as a dial-a-bus service. With all the money at stake the market for MaaS will be hotly contested (see Deloitte 2017c, p. 118 and Polis 2017, p. 4).

1.1.5 Think regionally, act locally

Everyone is familiar with the phrase “Think globally, act locally,” (Warren Heaps, 2010) advising people to consider the health of the entire planet, while start acting in their local community. For the mobility sector this means to maintain a regional perspective to create collaborations across country borders as well as across industry borders. At the same time, the future of mobility will be designed on a local level led by cities and municipalities responsible for transport planning.

Compared with other countries, Europe is seen as being led rather than being in the lead when it comes to mobility services, as firstly it lacks economic policy initiatives and secondly the uptake among users is low. In terms of its regulatory framework, Europe is even seen as a mere follower, whereas countries like China, the United States, or Singapore are currently the pioneers in this field (see Roland Berger 2017, p. 10). However, German automakers are an exception here. A comparative analysis of more than 100 key actors, including digital players, has shown that Daimler, BMW, and the Volkswagen Group are offering the most wide-ranging portfolio of mobility services so far, and are clearly ahead of U.S. OEMs like GM, Tesla, and Ford (see Figure 3). It has to be said, however, that the depth of service offered by some big data players, like Uber or Didi Chuxing, is much deeper and their customer numbers are considerably higher (CAM 2017, p. 10). The automaker with the strongest portfolio is the joint venture of BMW Group and Daimler AG, which offers attractive mobility services such as FreeNow, ShareNow, and Moovel. New business models or products cannot be developed or operated single-handedly, however. And while the automotive industry has been trying for a long time to keep new players out, it has finally come to realize that it is better to make “frenemies” of one’s foes – that is to say to accept and collaborate with them to drive the development of new technologies. This is why collaborations with big data players like Apple, Baidu or newcomers like Lyft, Gett, and others are important for the further development of mobility services (CAM 2017, p. 7).

The local level will have an important role to play with regard to what the future mobility services will look like and whether the new offerings can have a positive impact on climate protection (see Strategy& 2017, p. 15). Cities and municipalities are not only in charge of transport planning, roads and parking, they also operate municipal public transport and have a say in decisions about the design of integrated mobility services. For example, in 2020 the city of Paris limited e-scooter providers to three vendors only (Abboud 2020). And in view of the increasing scarcity of space combined with more and more traffic and the ever-greater mobility needs of people, pressure is growing in urban areas to take transport planning action. Robo-cabs or autonomous driving are key to easing this pressure, but whether, on balance, they will have a positive or negative impact on the environment and the climate is yet to be seen. The first autonomous shuttle busses started operating on German roads in 2020 and are likely to develop dynamically.

Mobility service strength of global automakers

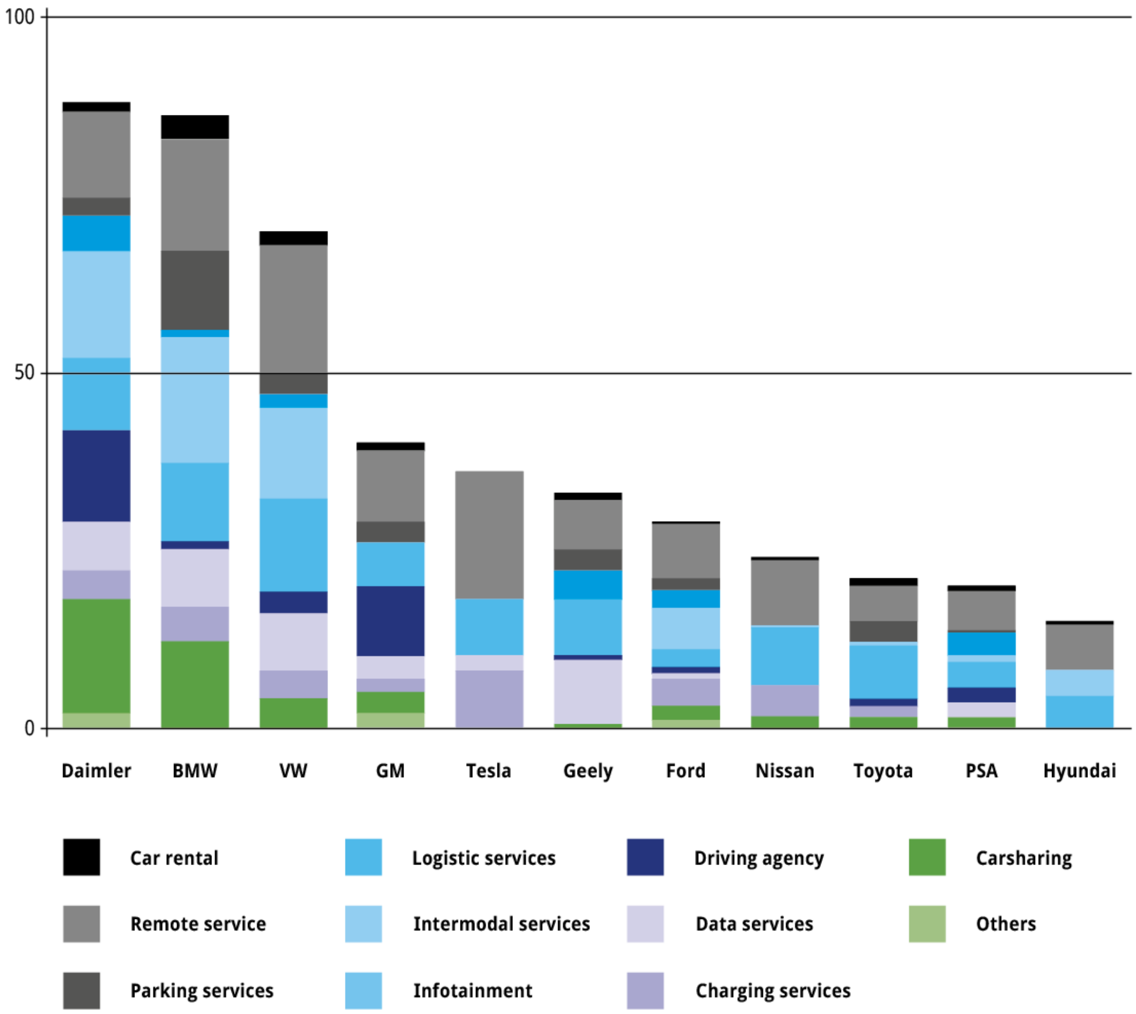

Figure 3: Mobility service strength of global automakers 2017 (Bratzel & Thoemmes 2018, Fig. 8, p. 55)

Studies have forecasted that, by 2030, autonomous driving and sharing schemes (carpooling, ridesharing) will already account for 37 percent of car traffic (see Strategy&

2017, p. 4). It is to be assumed that the automation of driving will have a significant impact on the pricing structure and consequently the use of mobility services (see Roland Berger 2017, p. 5). Calculations have shown that robo-cabs could be up to 60 percent more cost-effective than conventional cabs (see Roland Berger 2017, p. 6). The possibilities of combining autonomous taxis with sharing schemes have huge potential to reduce the amount of traffic. What is not clear, however, is whether and how to tap this potential, given the current regulatory framework (such as the German Passenger Transportation Act, Personenbeförderungsgesetz, PBefG), statutory regulations on autonomous driving, and others (permissions granted under the experimenting clause in § 2 (7) PBefG could allow for an interim step (see KCW 2017, p. 35). An environmentally friendly flanking and alignment of the political regulation or incentive structures will be crucial in this regard, particularly at local level. This includes integrating autonomous driving services in a multimodal transport system.

1.2 Infrastructure

Intermodal mobility services have big economic potential and can generate positive climate and environmental effects in the transport sector. The core idea of MaaS should be the primary principle for setting the regulatory framework. This means providing attractive value-added services for all citizens by ensuring a seamless, secure, and cost-efficient mix of transport modes that makes the use of private cars unattractive. For innovation in the mobility sector, too much and too rigid regulation must be avoided as it would hinder private-sector investment and involvement. Too little regulation, on the other hand, could – in a highly dynamic and not yet fully established market – lead to undesirable side effects of increasing environmental pollution and traffic (see Deloitte 2017b, p. 123). Considerations about the necessary infrastructures for MaaS include interoperability, data sharing and flexible regulation. Additionally, the role of public providers must be taken into account and future decisions will have far-reaching consequences for the development of the market and transport (see Holmberg et al., 2016, p. 7).

1.2.1 Interoperability

Many material infrastructure preconditions for MaaS are identical to those for autonomous driving, especially where high bandwidth and low latency 5G infrastructure is required. Furthermore, aggregating data in real time across a multitude of providers from different businesses, optimizing the data through algorithms for individual customers according to their preferences, and enabling them to book a service and pay with single sign-on within the same app – all this is pretty demanding on the infrastructure. To do this successfully requires the collaboration of a diverse range of actors, such as mobility service providers, telcos, public and private transport companies, and municipal planning authorities. This is supported by various studies that place utmost importance on innovative private businesses working together with public transport providers and authorities as collaboratively as possible when implementing MaaS. New forms of cooperation have to be practiced here as these collaborative models are unfamiliar to administrative bodies, for example (see Polis 2017, p. 2).

1.2.2 Data sharing

To ensure fair competition, access to the interfaces of applications (APIs) of the transport service providers must be the same for all MaaS initiatives, i.e., without exclusive rights, regardless of size of the provider. Only this can prevent monopoly structures, which would allow individual providers to foreclose ecosystems and exclude competitors. The innovativeness and creativity of small providers should not be restricted through customer lock-in by established players (see MaaS Alliance 2017, p. 16). Data providers, too, could become an important infrastructure component for interoperability of mobility platforms. Their role in the MaaS business model is that of an independent third party between different mobility service providers and their passengers. This “middle layer” may be crucial for eliminating barriers to cooperation because open data-sharing between MaaS providers that are in direct competition with each other has been a challenge (see MaaS Alliance 2017, p. 12).

As part of the interaction between public and private MaaS providers, the regulation of the use of data must also be clarified. It will be key to the success of the further development of MaaS that the providers of integration platforms (mobility operators) have open access to status data of all integrated transport modes (see MaaS Alliance 2017, p. 14). Commercial rules of cooperation between the various MaaS providers must also be established. When a platform provider like Moovel or Qixxit combines multiple providers, such as rail companies, cycle hire and transport service providers, rules need to be set up about what commissions are to be paid and who should get what percentage of the total ticket price. Further rules are required for the payment models offered to customers by the operator of a multimodal app: day passes, weekly or monthly passes as a subscription or pay-as-you-go solutions. In practice, agreeing such rules in cooperation between all providers is often a sticking point (see Deloitte 2017b, p. 121). Reciprocal digital access of providers to routes, timetables, stops, prices, and payment terms are further points to be considered in this context. The EU-wide harmonization of passenger rights in multimodal transport chains would give providers and customers security and could become reality in the early 2020s (see MaaS Alliance 2017, p. 17).

1.2.3 Flexible regulation

The regulation of transport systems has until now been based on historically grown structures that are sector-specific and not harmonized. This tends to be a hindrance to the development of intermodal mobility schemes (see MaaS Alliance 2017, p. 13 and Polis 2017, p. 4). These new service offerings are difficult to reconcile with the current rules of commercial passenger transport or have in individual cases already been banned by legal action (UberPOP; see KCW 2017, p. 5). Highly interconnected transport systems operated in collaboration between public and private companies seem to be indispensable for the intelligent urban transport mix of the future. This includes a regulatory framework to control traffic flows, which does not lead to one sector being privileged over others. At a European level, generic value chain illustrations for MaaS have been available since September 2017, which appear to be suitable for schematizing the interaction between transport modes (service providers), data aggregators (B2B aggregators), and platform operators (MaaS operators) and managing regulatory interventions (see MaasAlliance 2017, p. 8).

1.2.4 Public transport

Mobility services can help public transport operators, for example, in securing existing price advantages through the consistent involvement of privately operated autonomously driven taxis. This would then allow them to offer intermodal door-to-door services and discontinue little used bus services while also increasing the security of supply and the comfort of their passengers. Bus-on-demand pilot projects (which can be regulated in accordance with § 42 PBefG, on-demand regional transport) are already under way (see link). An additional regulatory requirement could be, for instance, that private operators must agree to offer 24-hour availability (see Roland Berger 2017, p. 21). The opportunities offered by such models for private mobility service providers are obvious: business expansion combined with guaranteed income and, as a result, certainty for longer-term investments.

1.3 Competitiveness

The innovative strength of the top 30 automakers has been analyzed based on 649 connected car innovations (CCI) in the fields of assistance and security systems, operating and display concepts, and information and communications systems of 2018/19 based on both quantitative and qualitative criteria.

CC index ranking by automaker

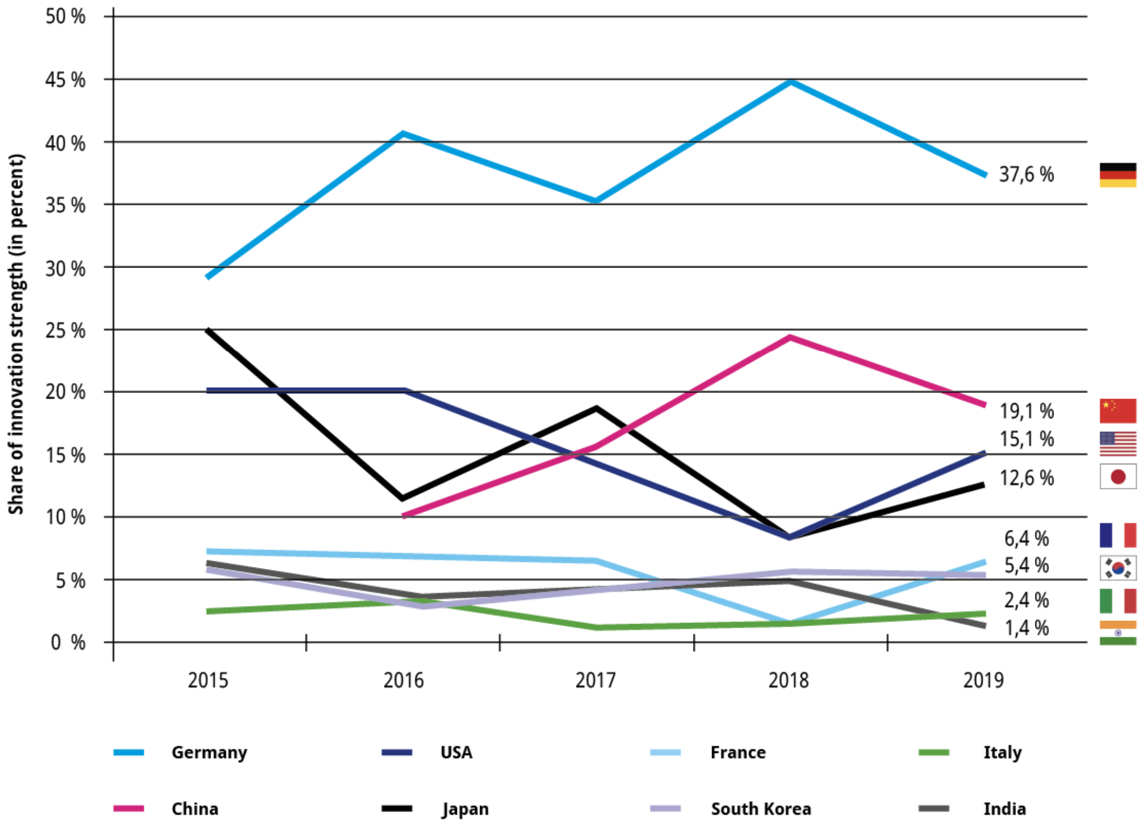

Figure 4: CC index ranking by automaker, 2018 (Bratzel 2019)

According to this analysis, the three German automakers continue to deliver a strong performance: In the CCI ranking, Daimler has relegated the VW Group from first to second place with a firework of innovations, often at remarkably high standards of quality (see Figure 4). BMW has dropped down from second to third place compared with the previous year. In contrast, the ranking of OEMs with a strong sales performance, such as Toyota (11th place), GM (23rd place), or Nissan (25th place) has been rather underwhelming (see Figure 4).

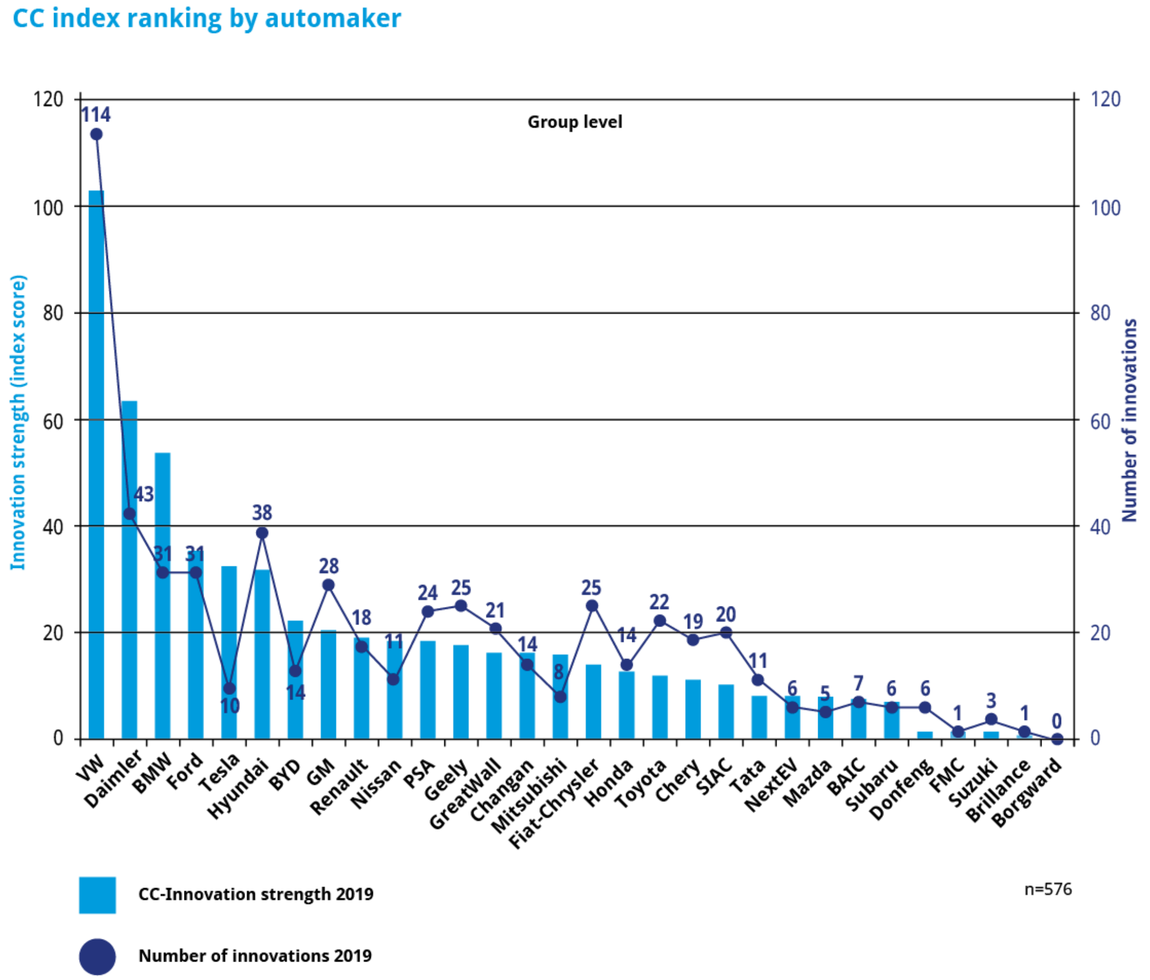

Figure 5: CC index ranking by country, 2018 (Bratzel 2019)

What the ranking most clearly reveals is this: Chinese car manufacturers are on an upward trajectory in term of their innovative power in connected-car technologies. There are no less than nine automakers from China among the current ranking's top 20 – more than ever before. With Geely (which includes Volvo), a Chinese automotive company has reached fourth place for the first time, followed by SAIC in seventh and NextEV in tenth place. The manufacturers from Europe, Japan, and the U.S. are under growing pressure from the new Chinese competitors and many of them will need to make a great leap forward to catch up. In the country group ranking, Chinese manufacturers are already in second place, after Germany, and far ahead of automakers from Japan and the U.S. (see Figure 5).

1.3.1 Mobility

The analysis of mobility services shows that although some automakers are shifting their innovation portfolio increasingly toward connected services, it is platform providers like Uber that must be reckoned with as a growing force in the mobility ecosystem. From a total of around 500 individual services examined, most services to be found are ride-hailing services – 165 current offerings were identified here. This is followed, at some distance, by various car-sharing services and then, very closely, by charging and parking services. The result: Only one third of the established car manufacturers is offering mobility services on a broader scale. Two thirds of the OEMs are – if at all – only involved in small pilot projects, for instance in the area of station-based as opposed to free-floating car-sharing. Overall, the evaluation of mobility services shows Daimler and BMW are clear leaders (see Figures 2 and 4). In 2019, the two groups even pooled most of their mobility services in what is their joint venture YourNow in order to realize more synergies (McGee 2019). If we include mobility providers and digital groups in the spectrum of mobility services, Daimler and BMW are followed by Didi Chuxing and Uber in third and fourth place respectively, which puts them clearly ahead of Volkswagen and Ford.

1.3.2 China dominates

Apart from the automakers' innovative strength, it is primarily the market footprint and digitization push of big data companies that plays a key role in mobility transformation. Measured on the basis of various indicators, the picture that emerges from the country comparison is clear: Although Germany has OEMs with great innovative strength regarding connected cars and new mobility, it is also in many respects a developing country in digital terms, with poor digital strength and a lack of credible big data players. China on the other hand is a completely different story. The country has not only a high degree of connectedness and digitization as well as high revenue volumes, it also has its own major big data players, such as Tencent, Baidu, Alibaba, or Didi Chuxing, who are driving the development of connected services. Collaborations between automakers and big data players are becoming increasingly important to our future connected mobility. The enormous digital strength of their home country is a boost to Chinese automakers and helps them improve their standing, including – with the support of western automotive suppliers – in the area of connected-car innovations.

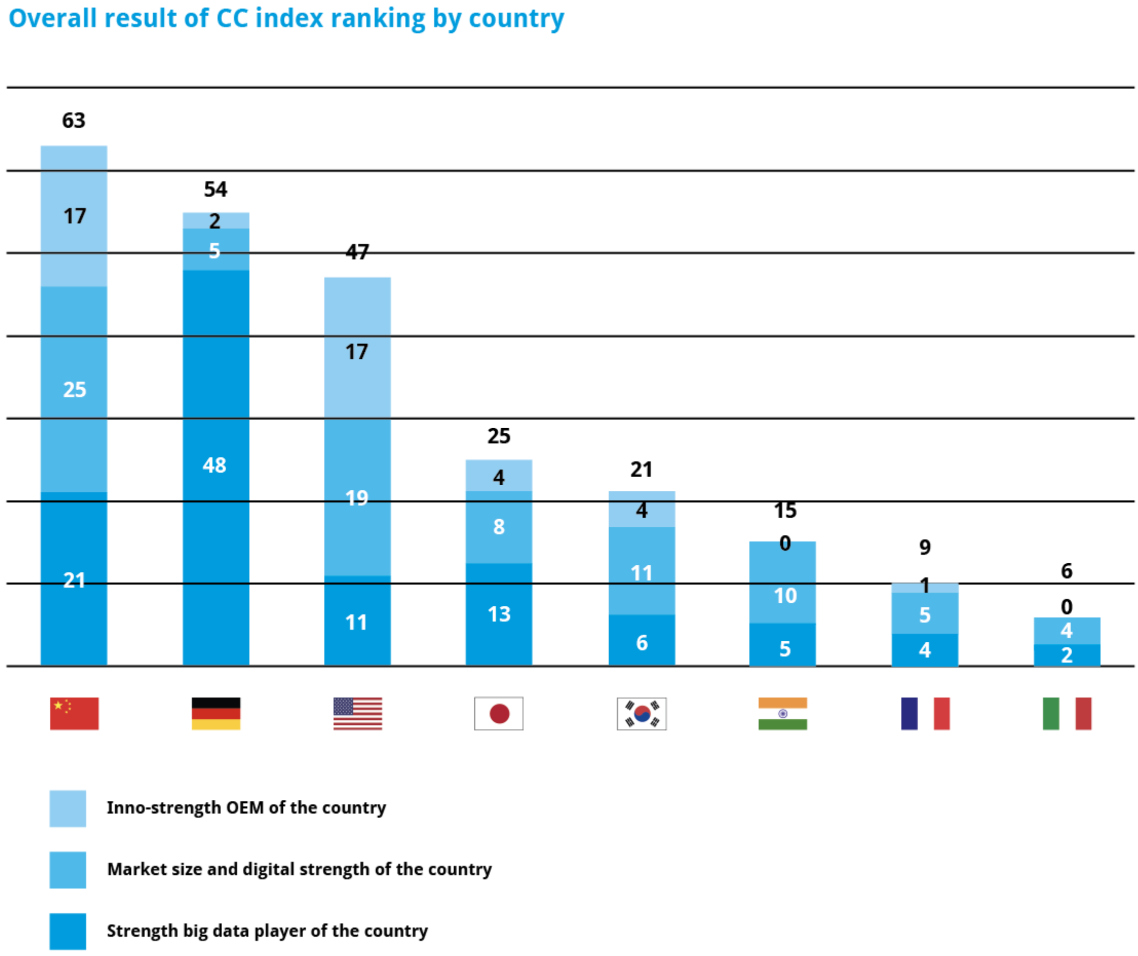

Figure 6: Overall result of CC index ranking by country, 2018 (Bratzel 2019)

The overall picture in terms of the major automotive countries' connected-car strength shows that China is consolidating its lead over Germany and the United States, whereas the other automotive countries – particularly Europeans – are falling behind (see Figure 6). While there is a healthy balance between big data players, market size, digital strength, and innovative power in the area of connected cars in both China and the U.S., the U.S. seems to be falling behind in the area of connected cars. Germany's strength is almost exclusively based on the innovations of its automakers, and the digital weakness of their home country could turn out to be a hindrance for German car manufacturers in their efforts to drive innovation.

1.4 Conclusions

Auto-mobility and transport are in for a structural reset and will change more profoundly than they have done since Henry Ford industrialized the business in the 1910s with the introduction of the moving assembly line that made individual motorized mobility affordable for the public. Today, digitization is reaching automotive and converging with new technology, such as electrification and autonomous driving, as well as socio-cultural and political change. All of it is coinciding with climate change and a saturation of urban spaces to create a perfect storm. The automakers may well be – for the first time ever – faced with a struggle for relevancy and survival that could have significant implications for value creation and jobs in Europe. A dollar can only be spent once, and therefore, at the core, companies have to sort out where to play: continue to make and sell hardware, create a mobility service business, do both or focus on niche opportunities. In some domains, companies either focus on making hardware (airplanes) or services (airlines). In other areas, companies are vertically integrated (Apple's iPhone, apps and services). Focusing on one versus the other may come with unintended consequences, such as industry consolidation. For example, while there are many airlines, the West is left with only two makers of big commercial airliners, Airbus and Boeing.

In light of the above challenge, this paper discussed strategic pathways in auto-mobility and asked which mission-critical infrastructures or enabling conditions need to be created in order to promote innovation and strengthen transformation capabilities in the auto-mobility sector.

The paper points out how trends such as the growing importance of mobility services will influence the market – not only for automakers. For one MaaS can be very attractive for cities and regions in order to prevent the threat of urban traffic collapse, to achieve climate protection targets, to reconfigure the use of space, and to ensure better quality of life as a result (see Holmberg et al. 2016, p. 10ff). For another MaaS can also be highly attractive for customers as it offers flexible and personalizable door-to-door mobility, which can be delivered affordably – if not today, then tomorrow with new technology, such as autonomous driving.

To enable the potential of MaaS, flexible regulation will be required. One successful example is regulation to allow electric scooters on German streets in 2019. Regulation can ensure that new technology is complementing traditional services, such as public transport and the taxi business (see KCW 2017, p. 58), increase efficiency for providers by matching demand with supply and generate data on mobility behavior for a data-driven traffic planning in cities.

Furthermore, mobility services can provide incentives to change consumer behavior by offering alternatives to private car ownership. The customer will have access to a portfolio of multi- and intermodal mobility options right at his doorstep. The design and configuration of mobility services will have a huge impact on transport development and people's mobility behavior as well as on the environmental and climate contribution of Germany's transport sector resulting therefrom.

Companies must find pathways to migrate toward their new positioning. Regardless of positioning, whether the focus is on making things or providing a service, overall, expertise in software, data and analytics will be required. Particularly data seems to have been neglected and for quite some time in Europe. While Amazon, Facebook and Google – and Alibaba, Baidu and Tencent – have collected vast pools of valuable user behavioral data in real-life (just look at their market capitalizations; Schlueter Langdon 2019) ... often with GPS location stamps ... very little has happened in Europe. Here it may be essential to partner, pool interests to pool data in order to catch up.

References

Abboud, L. 2020. Three companies win e-scooter licences in Paris - Lime, Tier and Dott selected to operate in Europe's largest market. Financial Times (retrieved July 23, 2021), link

Bratzel, S. 2014. Die junge Generation und das Automobil – neue Kundenanforderungen an das Auto der Zukunft? In: Ebel, B., M. B. Hofer (Hrsg.): Automotive Management. Strategie und Marketing in der Automobilwirtschaft, 2. Auflage, Heidelberg: 93–108

Bratzel, S. 2020. Automotive Innovations 2019 and Electromobility Report 2020. PU Magazin (retrieved February 2021), link

Bratzel, S. 2019. Die Automobilhersteller im ‚Kampf der Welten' – Connected Car Innovation 2019. Mobilitätswende, Die Zukunft der Automobilindustrie, Sonderveröffentlichung Handelsblatt Journal (retrieved October 24, 2021), link

Bratzel, S., and R. Tellermann. 2017. Die Innovationen der globalen Automobilkonzerne. Eine Analyse der Zukunftstrends und Innovationsleistungen der globalen Automobilhersteller und Zulieferer, Bergisch Gladbach, CAM Arbeitspapier (June), p. 29

Bratzel, S., and J. Thoemmes. 2018. Alternative Antriebe, Autonomes Fahren, Mobilitätsdienstleistungen – Neue Infrastrukturen für die Verkehrswende im Automobilsektor. [Alternative engines, autonomous driving, mobility services – new infrastructures for the transport transformation in the automotive industry.] Heinrich-Böll-Stiftung, Schriften zu Wirtschaft und Soziales [Papers on Economic and Social Issues], Volume 22, Berlin, link

CAM. 2017. CCI 2017 – Connected Car Innovation Studie 2017 (Summary), Bergisch Gladbach, CAM Arbeitspapier in Zusammenarbeit mit carIT, (retrieved July 2021), link

Citroën. 2016. CSA Research/Citroen: Our Lives Inside Our Cars. European Survey (August)

Clean Energy Partnership, online: link (retrieved December, 15 2017)

Deloitte. 2017b. The rise of mobility as a service, Deloitte Review 20, link (retrieved December 5 2017)

Deloitte. 2017c. Governing the future of mobility, Deloitte Center for Government Insights 2017, link (retrieved December 6, 2017)

Ford, H., and S. Crowther. 1922. My Life and Work. Garden City Publishing Co., Inc.: Garden City, New York

Holmberg, P.E., M. Collado, S. Sarasini, and M. Williander. 2016. Mobility as a Service – MaaS, Victoria Swedish ICT AB, funded by Vinnovia (January), link (retrieved December 8, 2017)

KCW. 2017. Gutachten Reformbedarf PbefG. Rechtsrahmen für Mobilitätsangebote mit flexibler Bedienung unter besonderer Berücksichtigung des Bedarfs in Räumen und für Zeiten mit schwacher Nachfrage, Endbericht erstellt für die Bundestagsfraktion Bündnis 90/Die Grünen, Berlin, link (retrieved December, 8 2017)

MAAS Alliance. 2017 – Guidelines & Recommendations to create the foundations for a thriving MaaS Ecosystem, White Paper, MaaS Alliance, Brussels (September), link (retrieved December 5, 2017)

McGee, P. 2019. BMW and Daimler to invest €1bn in mobility joint-venture. Financial Times (retrieved February 22, 2019), link

Naughton, K. 2020. Ford Elevating Farley to CEO After Hackett's Bid Falls Short. Bloomberg (retrieved August 4, 2020), link

POLIS. Hoadley, S. (Ed.) 2017. Mobility as a Service: Implications for urban and regional transport, Discussion Paper offering the perspective of Polis member cities and regions on Mobility as a Service (MaaS), Brussels, (September 4), link (retrieved December 4, 2017)

Roland Berger. 2017. Urbane Mobilität 2030: Zwischen Anarchie und Hypereffizienz, Szenario Analyse (Oktober), link (retrieved December 14, 2017)

Schlueter Langdon, C. 2019. One Future of Auto is Airlines – Yield Management Systems to the Rescue (Auto 3). Working Paper (WP_DCL-Drucker-CGU_2019-08), Drucker Customer Lab, Drucker School of Management, Claremont Graduate University, Claremont, CA (link)

Schlueter Langdon, C. 2019. The Auto Power Shift to Data: From Asteroid to Data Sandwiches and Exchanges (Auto 2). Working Paper (WP_DCL-Drucker-CGU_2019-01), Drucker Customer Lab, Drucker School of Management, Claremont Graduate University, Claremont, CA (link)

Schlueter Langdon, C., and A. Bau. 2007a. Portal Economics. Digital Interactive Channel

Systems and Portals Structure and Economics. In: Tatnall, A. (ed.). Encyclopedia of Portal Technologies and Applications. IGI Global: Hershey, PA; London: 249-255

Schlueter Langdon, C., and A. Bau. 2007b. Portal Economics and Business Models - Pitfalls, Lessons Learned and Outlook. In: Tatnall, A. (ed.). Encyclopedia of Portal Technologies and Applications. IGI Global: Hershey, PA; London: 719-723

Schlueter Langdon, C., and M. J. Shaw. 2002. Emergent Patterns of Integration in Electronic Channel Systems. *Communications of the ACM* 45(12): 50-55

Schlueter Langdon, C., and M. J. Shaw. 1997. A Strategic Framework for Developing Electronic Commerce. *IEEE Internet Computing* 1(6): 20-28

STRATEGY &. 2017. The 2017 Strategy & Digital Auto Report (September), link (retrieved December 14, 2017)

2 Dataspaces Enabled Mobility

Prof. Dr. Christoph Schlueter Langdon

Data! Finally! The reckoning of the complexity of data has arrived in the C-suite. Data natives saw this coming ages ago. A deep understanding of data and its complexity has always been a key ingredient of good science. But in business it was a bit like fighting windmills – like Don Quixote – until the 2020 Coronavirus tragedy hit. The pandemic unexpectedly put data in the spotlight and turned it into front-page news. Yes, CEOs and business pundits have been talking about "data as the new oil." Yet, with the Corona crisis, all of us are suddenly debating new variables such as the R0 rate, pronounced "R-naught," which represents the number of new infections estimated to originate from a single case. And suddenly key concepts to evaluate the quality of scientific research, reliability (consistency of measures), and validity (accuracy) made sense to everyone. The crisis pulled data and its complexity out of the shadow and into the limelight.

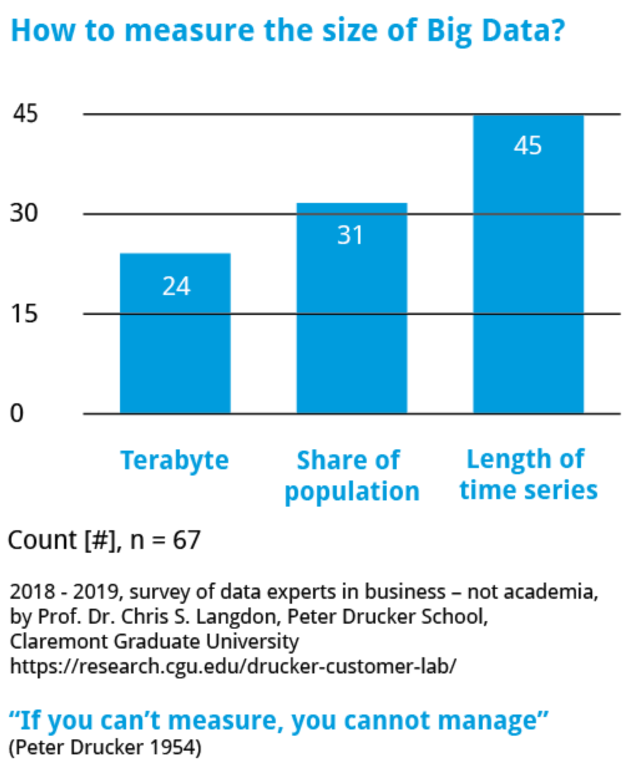

Figure 7: Data measurement dilemma

In the past, if I asked an audience who had taken a statistics class, all hands would go up. But no one would volunteer to quickly explain a t-test. If I asked about data, nobody had taken a class, but everybody would be eager to explain it. So, it was easy to peddle stereotypes, omitting deeper issues, such as data sharing and pooling architectures, and data rights management and governance (e.g., Otto 2011). Even supposedly straightforward issues, such as sizing data, how to measure the quantity of data, has remained surprisingly tricky to this day. We know to buy eggs by the dozen, a pound of butter, and a liter of milk. But how do we buy data? By byte or length of a time series or share of population? Figure 1 illustrates this data sizing dilemma.

2.1 From centralized storage and data lakes to data spaces

The Coronavirus pandemic has upended long-held beliefs in data handling. A prominent example is centralized data storage. It may just be a human habit or a trait and second nature, or even biological. Because humans were hunter-gatherers and stashing food away for bad times was critical for survival (Stephens et al. 2019). Even today any accountant would confirm that there is efficiency in a centralized data stash, as one building is cheaper than two for the same space. So, data was kept centrally because it felt better, and the numbers backed up intuition. Then social media happened, and data became a legal headache: How can we protect data privacy? Well, don't collect it in the first place, or lock it away, the lawyers would advise. Now, it felt better, the numbers were better and ... well, who would put a career at risk and argue against lawyers? Then suddenly data scientists emerged waving artificial intelligence (AI) like a magic wand asking for more and more data to create secret formulas or algorithms like those by Amazon, Facebook, and Google. Now it became uncomfortable because who could argue with trillion-dollar market capitalizations? So, something had to be done. Fortunately, none other than Harvard Business School's esteemed strategy guru Michael Porter (Five Forces, Value Chain), a consultant favorite and appreciated in the C-suite, came to the rescue. Together with James Heppelmann he wrote a seminal piece on Smart Products and the Internet of Things (IoT) and advocated: "Create a data lake" (Porter & Heppelmann 2015, p. 109). Today, it has become clear that such centralization is giving way to a more distributed way of creating data pools required for AI.

For one, small companies with only a little data would be left high and dry; this is a no-brainer particularly in Germany with its strong medium-sized companies, referred to as "Mittelstand," which collectively form the backbone of its economy. For another, in Europe, even companies at the other end of the spectrum, the biggest firms in Europe, the 800-pound gorillas, the seemingly unbeatable, are experiencing difficulties in catching up with hyperscalers and first movers from the U.S. and China.

The automotive industry is a case in point. Let's consider autonomous driving. For some time, the industry has been debating whether video data is sufficient to train the best algorithm or whether additional sensors such as LiDAR ("Light Detection and Ranging" to measure ranges) would provide better data. It's a debate about ingredients and nutritional value: Is it better to use butter, or is margarine sufficient? It obscures the fact that regardless of butter or margarine the sheer volume of data is important, particularly for the type of AI used in this field (primarily neural network-based methods). And while the industry has been debating, a new entrant, Tesla, has been collecting. Tesla does not use LiDAR, which is still expensive, but video cameras instead. Tesla uses a large number of them and most importantly, it started doing so years ago. It suddenly leaves industry heavyweights that produce millions of vehicles annually playing catch-up.

How can anyone catch up and create vast data pools quickly? One solution is data ecosystems with data spaces. Business ecosystems are understood as broad configurations of actors operating in a loose setting (Moore 1996 and 1993, for an overview, see Tsujimoto et al. 2018). A data space is a loosely coupled system based on rules or standards for data governance to assure data sovereignty (Jarke et al. 2019). Loosely coupled systems have a rich history in the field of information systems, such as with web services, for example (Schlueter Langdon 2003a). They can provide the flexibility for best business fit with tight integration (Schlueter Langdon 2006, 2003b).

One prominent example of a rule-based data space approach is International Data Spaces (IDS). "International Data Spaces (IDS) is an initiative that promotes a virtual data space leveraging existing standards and technologies, as well as governance models to facilitate secure and standardized data exchange and data linkage in a trusted data ecosystem" (Otto et al. 2019a, p. 37). A core tenant of IDS is a virtual homogenous data layer with decentralized data storage, which in turn "provides a basis for creating smart-service scenarios and facilitating innovative cross-company business processes, while guaranteeing data sovereignty for data owners" (Otto et al. 2019b, p. 9). In 2020 IDS has emerged as a data space standard:

- It became a formal standard published as DIN Spec 27070 "Requirements and reference architecture of a security gateway for the exchange of industry data and services" (link, ordering at: link)
- "IDS is significantly involved in the design of GAIA-X" (BMBF, Federal Ministry of Education and Research, link), an upcoming, multi-year initiative of the German government: GAIA-X strives "to set up a high-performance, competitive, secure, and trustworthy data infrastructure for Europe" (BMWi, Federal Ministry for Economic Affairs and Energy 2019).
- First implementations are available, such as the IDS-based Trusted Connector of the Deutsche Telekom Data Intelligence Hub (link), which was launched as the first "IDS-ready" certified connector at HMI 2019 (Fraunhofer 2019) and which is applied in mobility, specifically in intermodal transportation, in the first laboratory of the National Platform Future of Mobility (NPM) from 2020 until

the end of 2021 in Hamburg (NPM, link).
- So, let's dig deeper and take a look at the digital transformation of the automotive and mobility business to discuss implications for data, specifically its organization and management in the context of data spaces and IDS.

2.2 From automotive to mobility

Automotive is out, mobility is in. People will still buy cars, but they will buy fewer of them, and the excitement is moving on … definitely in densely populated urban spaces and developed countries, maybe less so in rural areas and emerging markets. Such a shift has occurred before with other well-known technologies, like radio, for example. Radio technology and radio broadcasting as a business were a sensation; until television arrived. Video didn't kill the radio star as prophesied in the hit song by The Buggles, the first ever music video to be shown on MTV in 1981, yet TV greatly diminished radio's importance. And today TV itself is being pushed out of the limelight by mobile video platforms such as YouTube and Netflix. So, what should be done in automotive, how can a transition toward mobility be successful?

Merriam-Webster defines mobility as "the quality or state of being capable of moving or being moved." In big cities it is already evident how mobility is evolving from a product-centric and self-organized affair ("my car") toward a more seamless experience involving different modes of travel. New last mile solutions, such as shared bikes and e-scooters, and location data could allow for intermodal offers. Instead of walking to a destination after parking the car, the driver could accept an offer for a shared e-scooter nearby. Combining such last mile solutions with a parking recommendation, the driver could be navigated to an empty parking spot with a scooter or a van shuttle nearby.

Figure 22 illustrates how a simple trip from A to B could evolve toward seamless mobility (Schlueter Langdon 2019). It illustrates the evolution of personal mobility from a self-organized affair toward one that is orchestrated on behalf of a user in a seamless and personalized fashion. For example, a three-segment journey from point A to point B could evolve from car ride-parking-walking to one where the car is navigated to a parking spot that is available (smart parking) and with an electric scooter nearby (smart shared) for the last leg of the journey. The figure also analyses the two sides of the same coin: the user view and the provider perspective. From a user's point of view speed and comfort are important. For a provider the business model and profitability matters.

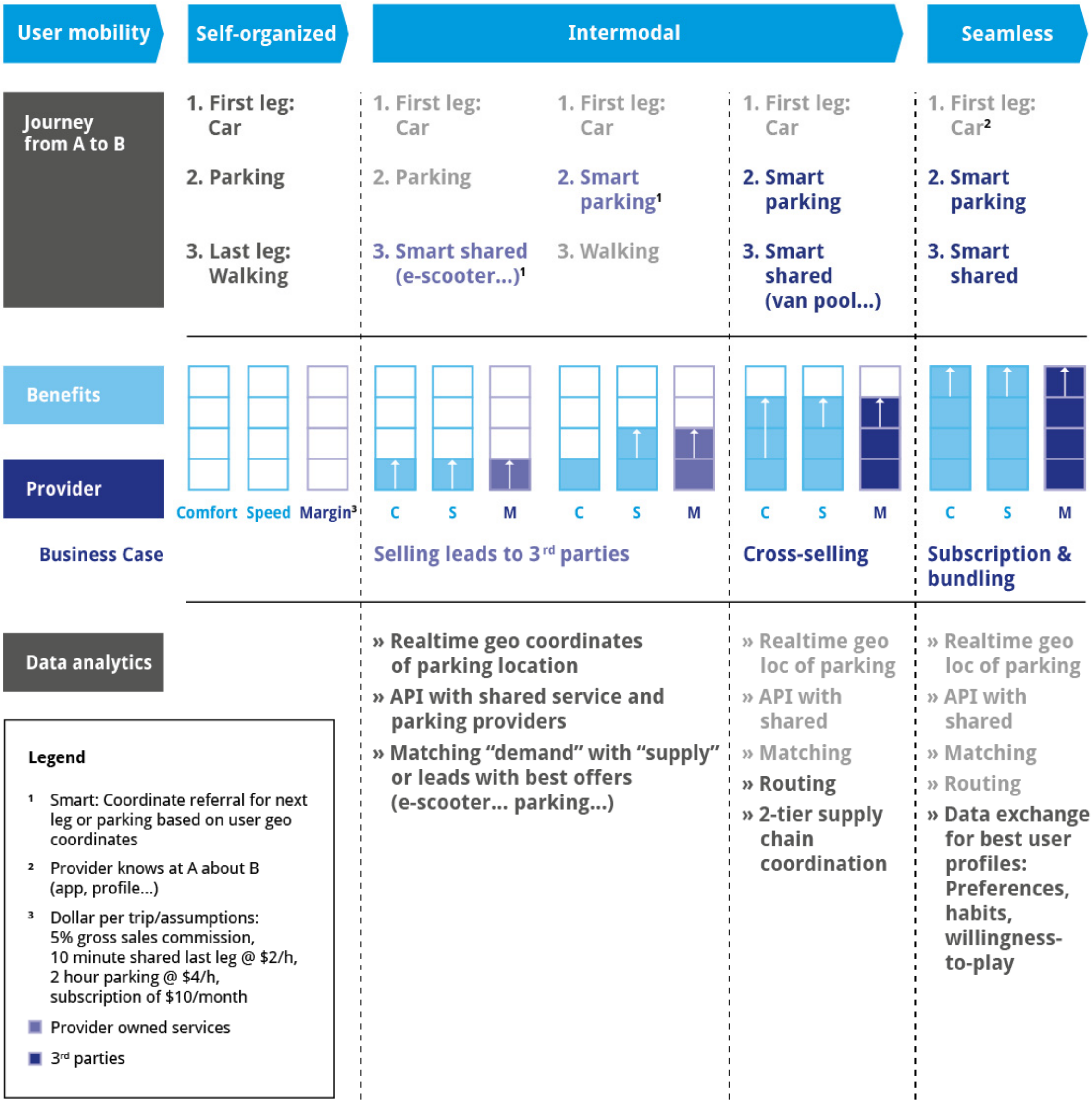

Figure 2: Economics of seamless mobility

The good news: The smarter the solution the bigger the benefits for both sides. This is no surprise as today's system is highly inefficient: cars remain unused for nearly 23 hours per day, are mostly used for single-occupancy trips, and parking often entails circling the block, etc. Our assessment is based on simulation experiments and pilots. The bottom part of the figure is a look under hood that dissects what a smart solution would entail and require.

While high-level, it nonetheless clearly conveys that data needs grow significantly with every step from self-organized to seamlessly orchestrated travel. What is interesting to see is how user benefits increase. Users can save travel time and enjoy increased comfort and convenience. Using a scooter is faster than walking, being navigated to an empty parking spot saves time searching and circling the block; and hopping into a shared van shuttle is probably more comfortable than both walking and riding a scooter. For mobility companies this is terrific news, because higher user benefits can translate into opportunities for higher margins (results based on our "Mobility-as-a-Service Calculator").

However, despite this lucrative outlook, few mobility companies are currently winning financially. Car manufacturers seem to be struggling. What is going wrong? For one, it takes a new success formula. Performance is no longer measured in revenue per vehicle but revenue per trip. For another, creating the right business system und underlying infrastructure seems to be a big challenge, because it is very different from traditional automotive business. Winning is no longer so much about cool cars, mastery of manufacturing, and dazzling dealerships. And it can't be fixed by recruiting star designers, powertrain mavericks, and slick salespeople. Optimizing results per trip requires an entirely different business and information systems infrastructure. A lot of the complexity of winning in mobility is hidden behind the word "*smart*" used in Figure 22 – the notion of an infrastructure designed "*so as to be capable of some independent action [...] having or showing quick-witted intelligence*" (Oxford English Dictionary). The good news – there is a solution that is familiar; it breaks down complexity into building blocks, which makes it manageable. It was invented in the airline business, another transportation business – and with spectacular success. While history won't repeat itself exactly, applying the lessons learned can help avoid mistakes and save time. So what happened and what can be learned from airlines? Lessons from last century's U.S. airline deregulation

In 1978 U.S. President Jimmy Carter signed the Airline Deregulation Act into law (Statue-92-pg1705, link). It was the first piece of deregulation (affecting routes and market entry) that torpedoed business as usual for U.S. carriers. A second piece in 1983 (reducing fares) threatened survival (Kahn 2007). Suddenly, low-cost startups invaded the business with much lower fares. Carriers like American Airlines, Delta, and United looked like dinosaurs facing extinction. Yet, fast forward 40 years, and those very brands are still alive – dominating the U.S. market. *How* did they survive and dominate?

From the outside little seems to have changed. Today, same as 40 years ago, American, Delta, and United buy planes, paint them in their livery, and fly them from A to B. Yet, behind the scenes a lot has changed. Most importantly, carriers started with changing results. As Peter Drucker, the legendary founder of management science, said: "start with results, the rest will follow" (Drucker 1963). 40 years ago, airlines started to *shift from revenue per route to revenue per seat*. What seemed to be a minor tweak in a financial spreadsheet required large investments in new services and processes – and the systems and software to automate it all *("*softwarization*"* Schlueter Langdon 2003c). Fundamentally, the challenge was twofold: First, optimizing the new metric – creating algorithms or analytics *"engines,"* which is an analytics or *data science* task; then secondly, providing the data input to an engine and automating its outcome – deploying the algorithms into a living process, which is a systems and data engineering job.

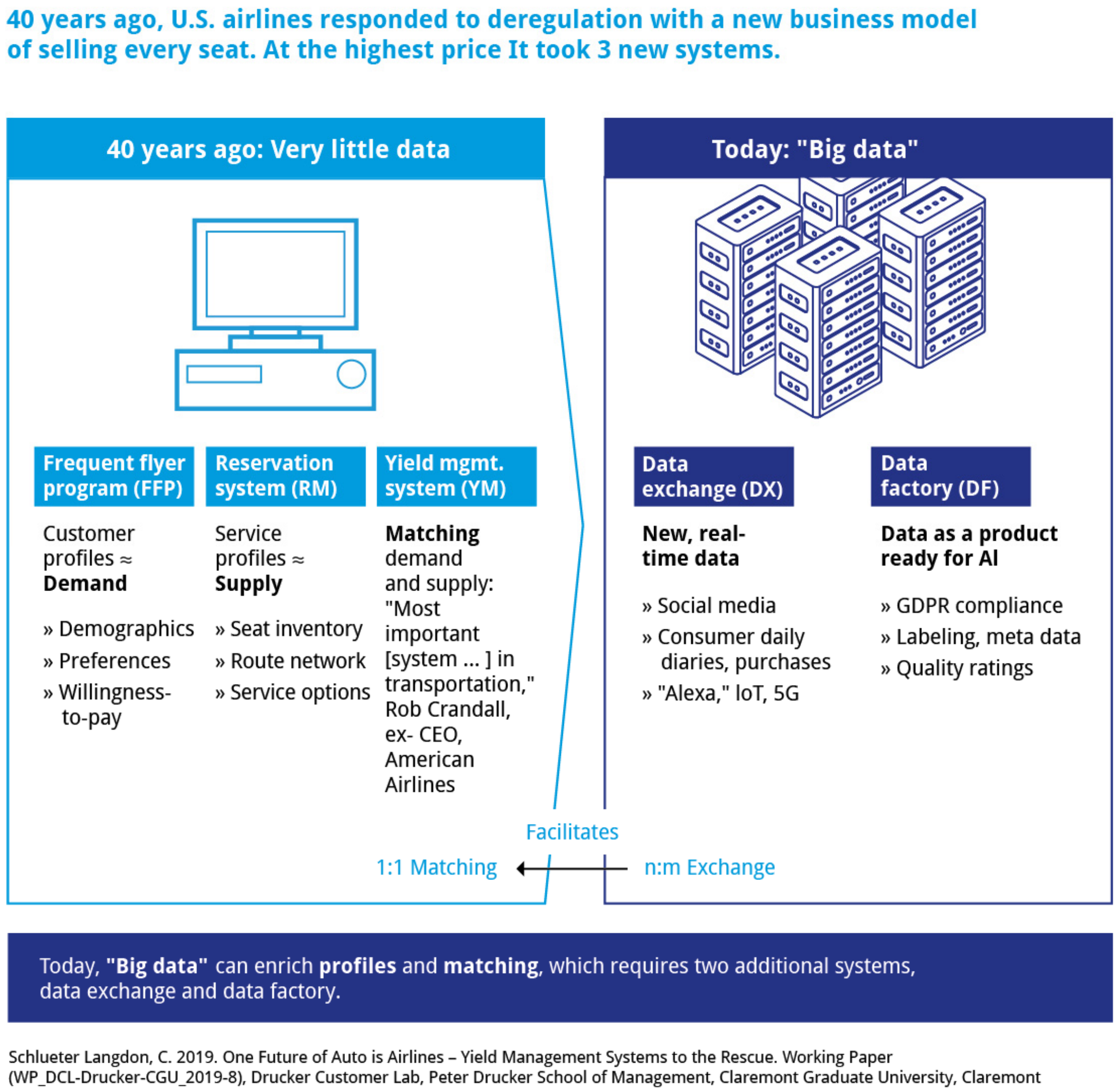

Figure 3: Industrializing the optimization of yield per unit of consumption

2.3 Three systems: two for data, one for analytics

Shifting from revenue per route to revenue per seat gave birth to three types of systems (see Figure 3, Schlueter Langdon 2019):

- An airline reservation system (ARS)
- A loyalty system for a frequent flyer program (FFP)
- A yield or revenue management system (YM)

Why these three systems? At the core of the shift to revenue per seat was the insight that profitability required *selling every single seat and at the highest price possible*, essentially treating seats as perishable goods and customers as NOT created equal. From an analytics perspective the challenge was doable: matching demand with supply, matching customers with seats.

It required coupling inventory management with variable pricing: Use seat inventory to determine supply, use customer profiles to predict demand, then use different price points to clear the market. Finally, learn from results and adjust inventory next time around, for example by using a bigger plane or adding a flight.

The problem back then was less with the analytics but more with the data – or more precisely, the lack of it. Where could the seat inventory for a particular destination be found? How is it possible to keep track of different routes to the same destination? For example, 5 seats in Business Class from Los Angeles/LAX to New York/JFK, and 10 seats for the same destination but via Chicago/ORD, and therefore, with a much longer travel time. Airlines created *reservation systems to manage inventory*.

And where can customer profiles be found to predict demand and establish price points? Selling each seat and at the highest price requires insights into a customer's willingness-to-pay (WTP). Predicting WTP, in turn, requires data on travel event type (leisure or business), budget (income or travel policy), sensitivity to travel time (daytime departure or red eye), travel duration (non-stop or stopover), convenience (economy class or business), and the decision context (traveling alone or with family) – and all of the above not at some aggregate, average level but for each potential traveler. In order to collect this data airlines invented *frequent traveler programs to create traveler profiles.*

Finally, the matching of supply -using the service profile data from the reservation system - with demand – using the traveler profile data from a loyalty system - is automated with a *yield or revenue management system*. Robert Crandall, former Chairman and CEO of American Airlines, gave yield management its name, calling it "the single most important technical development in transportation management since deregulation" (link); for American Airlines, see Smith et al. 1992; for a YM literature review, see McGill & Van Ryzin 1999; for state of YM, Carrier & Fiig 2018).

2.4 More data … two more systems

With a shift in results from revenue per car to revenue per trip, learning from airlines seems a very appropriate first step. Yet, three systems may not be sufficient anymore. The data situation has been reversed. 40 years ago, airlines faced a data drought. Today, there is a glut of data available that can add critical value and should be utilized. 40 years ago, smartphones did not exist. Today, in developed countries almost every adult is using one, and the device itself has evolved into one gigantic data logger (Dezember 2018). Smartphones have been a key enabler of a trend that has been dubbed *"SoLoMo"* by John Doerr, a partner at influential Silicon Valley venture capitalist Kleiner Perkins in 2010 (Guynn 2013). It summarizes the expansion of digitization into social, local, and mobile applications, which has fueled growth of data on consumers and its commercialization for advertising and new service offerings. Companies like Facebook, Google, and Uber exemplify this trend.

Yet those high-profile firms are just the tip of the iceberg. Today, a vast cottage industry of consumer data brokers has emerged that sells consumer data.

For example, a new 2019 law in Vermont that requires data brokers to be registered (Vermont 2018) has already revealed more than 120 vendors of consumer data (Melendez 2019).

All this consumer data allows for better customization of offers by evolving from artificial and fictional *"personas"* with their inherent flaw of bias (systematic error) toward profiles cut from real-life behavioral data of actual and potential customers (McKinsey 2017, Crosby & Langdon 2014). Figure 4 illustrates the different data types available for constructing profiles today:

- data on consumers (traditional demographics, government statistics),
- data on products and services (from vendors),
- user-product interaction data (behavioral data), and a broad category of
- context data.

The latter ranges from capturing a consumer's daily diary and friends & family to environmental settings like weather and traffic conditions. For example, Uber's *"Pulse of a City"* provides a visualization of people traffic data (Belmonte 2015).

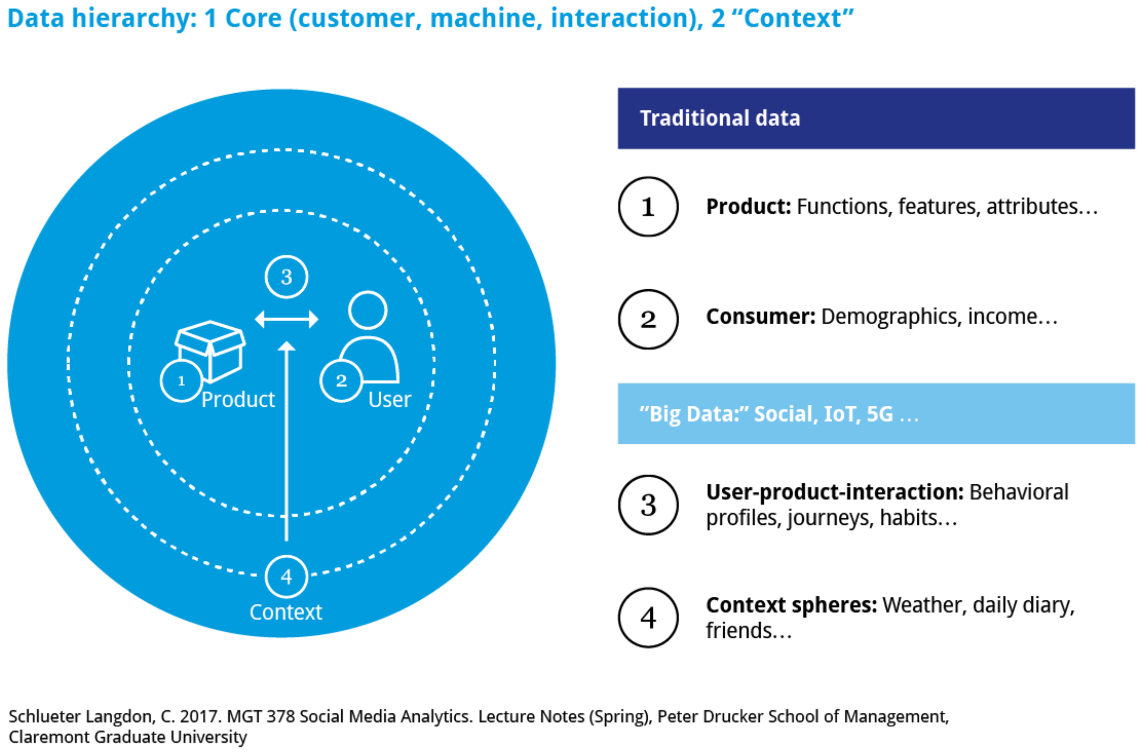

Figure 4: Enriching customization and personalization with Big Data

And much more data is expected. Again, new technology, such as 5G, a cellular mobile communication standard for higher speeds and bandwidth, and the Internet of Things (IoT) with bots and virtual assistants like Amazon's Alexa, will accelerate data creation (Crosby & Langdon 2017). To further complicate the data challenge, this data growth is happening everywhere:

- Within the enterprise
- Across a company's ecosystem of partners
- Externally

Let's take a car manufacturer, for example. Different departments collect data on the same customer: Market Research, Vehicle Development and – as vehicles are being connected for remote, over-the-air (OTA) updates and telematics – also Services & Parts and Financial Services.

And business ecosystem partners are also collecting data on the very same customer: dealerships, aftermarket vendors, insurance companies, payment processors, and various systems operators (concierge services, fleet maintenance providers, etc.). For best consumer profiles and most beneficial matching of users with "*seat inventory*" all this data ought to be considered – otherwise somebody else could make a better offer. It is a bit like battlefield intelligence in military applications: a better sensor, such as a radar system or night vision goggles, can create an immediate advantage.

2.5 Data exchange

This is where a data exchange system could add value. Think of it as a marketplace or "*supermarket*" with data products for data scientists. Today, according to meta-research, more than 80 percent of the time budget of a data analytics project is spent on data wrangling – not with algorithms (Press 2016, Vollenweider 2016). Companies have gone from databases to data warehouses and now to data lakes (Porter & Heppelmann 2015) – and they seem to be drowning in them. The question is – how can all this data be consolidated, organized, and made available to data scientists? An internal data exchange is one solution. Instead of searching for data across departmental silos and country operations, a data scientist could "*shop*" for internal data in a central location. This data hub could also connect with ecosystem partners as well as external, commercial data brokers to provide a single "*storefront*." It could track transactions for ease of auditing. It would also be a smart solution from a compliance and risk management standpoint. Instead of dealing with data regulation in a fragmented fashion, it could be standardized and enforced centrally.

In Europe, one example would be compliance with the General Data Protection Regulation (GDPR, European Commission 2018), which aims to give control to individuals in the EU over their personal data. An exchange could handle data anonymization and consent management of personally identifiable information centrally. With the Deutsche Telekom Data Intelligence Hub (DIH) there could be multiple data exchange options. Data could be exchanged peer-to-peer, directly between a data seller and a data buyer in a transaction brokered by the DIH (see "T-Systems as Pioneer: Implementing IDSA," link). The data could also be persisted on the Deutsche Telekom DIH and made available to buyers on a seller's behalf.

In any case, the DIH relies on IDS standards to ensure that firstly, only trusted partners can transact and that secondly, data will only be traded if binding usage restrictions to the data can be assigned, which creates a secure and trusted data space.

2.6 Data factory

As more and more data will be generated within a company using social media, 5G, or IoT, another system will be required. Call it a data factory. A data factory is needed to refine raw data into data products (Crosby & Schlueter Langdon 2019). Despite the hype surrounding data analytics and artificial intelligence (AI), raw data is still confused with refined data. Machine learning and AI methods require refined data products. This is obvious for data scientists but few in management seem to be aware of it. The food analogy can help illustrate the gap. Very few of us pick food from trees or slaughter animals; most visit a supermarket and pick food off the shelves. The food at the supermarket is processed, packaged, and labeled. Labels inform about product name, vendor, quantity, ingredients, and nutritional value. For example, a "*Nutrition Facts*" label in the U.S. can easily exhibit 20 rows of data (U.S. FDA 2016). These labels are no coincidence but the result of rules. These rules have evolved together with food processing to ensure product quality to protect consumers, because bad food can be a health hazard.

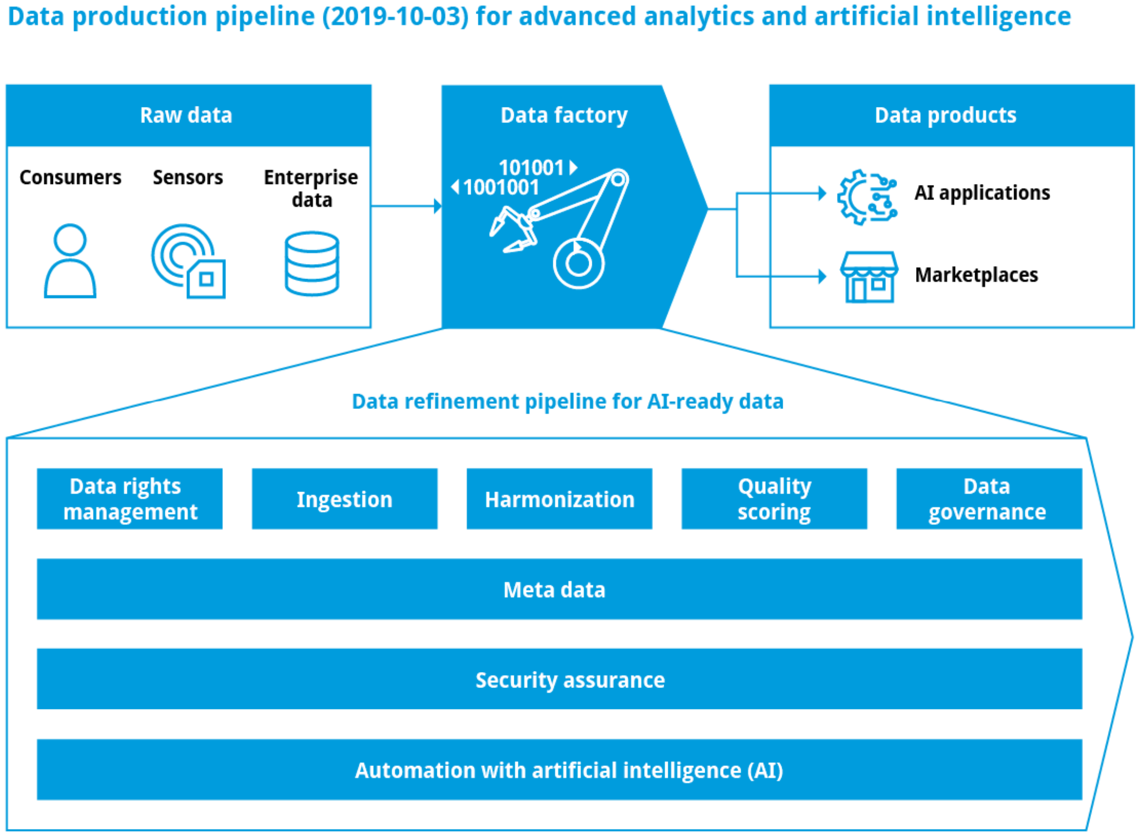

Figure 5: Data factory framework

In a nutshell, the food we buy is a product. It is processed, labeled, and packaged to be safe for consumption and exchanged for money. Machine learning and AI require data products. So, data could learn from food. For data to become a product it needs to be processed, labeled, and prepared to be safe for use and exchange. This data productization can be accomplished economically with a data factory. Figure 5 illustrates such a data factory framework (adapted from Schlueter Langdon & Sikora 2020).

In a nutshell, raw data rights must be verified before any data can be ingested or harvested (rights, licensing, user consent). Then data ought to be properly labeled or tagged for it to be made discoverable through a catalog of categories and search engines (classification). Furthermore, it needs to be scored to provide some indication of quality, because without it any subsequent analytics is pointless – "*garbage in, garbage out"* (GIGO, quality scoring). Finally, data governance mechanisms are required to ensure digital sovereignty for data owners making data available to be exchanged or shared.

2.7 Data spaces for trusted data exchange

Many AI applications, such as predictive maintenance or autonomous driving, can require more data than what is available within a single department and company. Creating data pools across companies would be an advantage (Otto et al. 2019b, Fig. 2.3, p. 15). For example, pooling all data of a particular machine type across all installations (horizontal pooling) would create a rich dataset for anomaly detection and its root-cause analysis. Another use case is pooling data vertically, across the participants along an entire supply chain or channel system in order to better estimate arrival times or ensure proper end-to-end temperature treatment of shipments, for example. In both situations, horizontal and vertical pools, outcomes would be best if most participants were to contribute. However, so far, few companies have been willing to engage in this type of data sharing. On the one hand, data is increasingly seen as a strategic advantage (the value aspect of "*data is the new oil*"), and therefore held closely and protected. On the other hand, more sensor data will only increase data pooling benefits. What has been missing are exchange options with data governance mechanisms that strike a balance between the need to protect one's data and share it with others (Otto et al. 2016; IDSA 2018a, 2018b).

Such data governance solutions are emerging. An important example are data spaces based on the reference architecture model (RAM) of the International Data Spaces Association (Otto et al 2019b). IDSA is an association of industry participants, created to promote data governance architecture solutions based on research carried out by the German Fraunhofer Institute with funding from the German government (Fraunhofer 2015). Members include car makers like Volkswagen, suppliers like Bosch, and traditional information technology specialists like IBM.

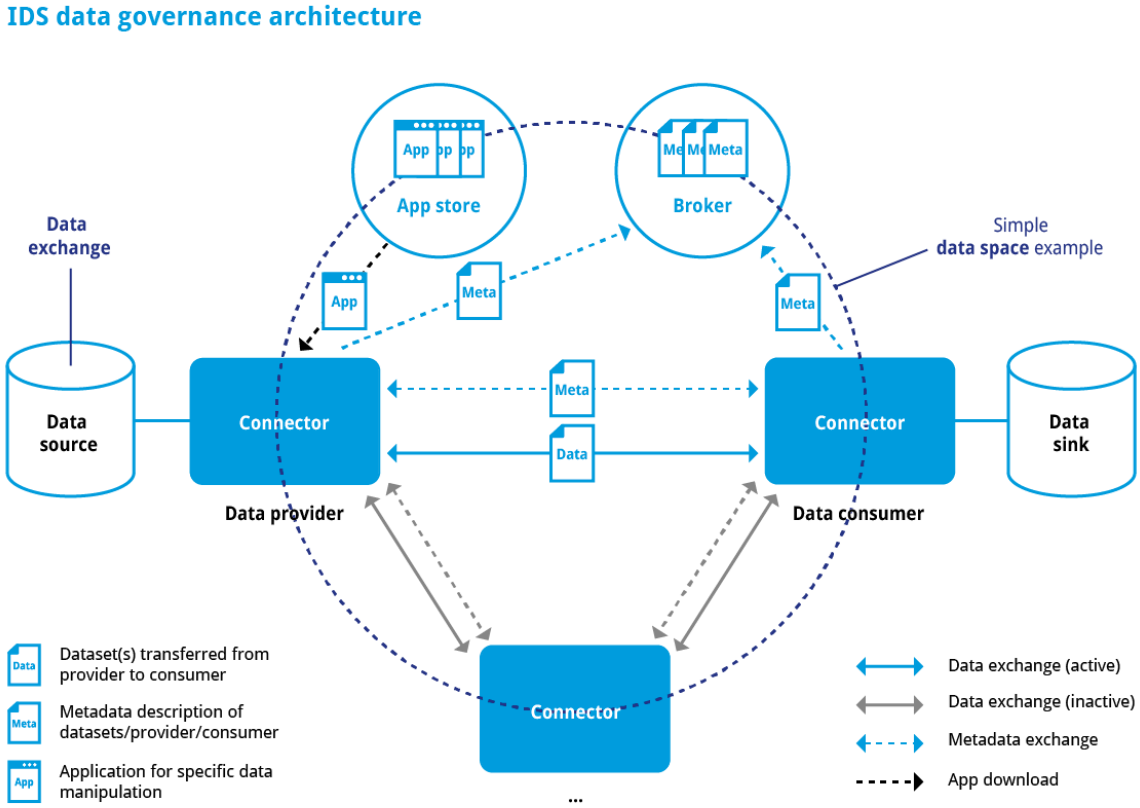

Figure 6: IDS data governance architecture

The core element of an IDS based data space is a "*connector*." It ensures that data rights can be governed. Figure6 illustrates the role of this element in the data flow between source (data provider) and sink (data consumer; Otto et al. 2019b, p. 59). With a connector, any data package or product can be "*wrapped up*" in instructions and rules for use. Technically, it is a dedicated software component allowing participants to exchange, share, and process data such that the data sovereignty of the data owner can be guaranteed. Depending on the type of configuration, the connector's tamper-proof runtime can host a variety of system services including secure bidirectional communication, enforcement of content usage policies (e.g., expiration times and mandatory deletion of data), system monitoring, and logging of content transactions for clearing purposes. As illustrated in Figure6, the functional range of a connector may be extended by (a) custom data apps, such as data visualization, provided in an app store and (b) a broker function to allow for product listings, such as a marketplace menu, and clearing services. A first connector implementation has been certified by IDSA for Deutsche Telekom's Data Intelligence Hub (Fraunhofer 2019).

2.8 "3 plus 2" is happening now

The shift in performance results from revenue per vehicle to revenue per trip can be managed and automated using several systems. U.S. airlines had invented three types of systems – two for data and one for analytics – to master a similar shift 40 years ago:

- An airline reservation system (ARS) for service inventory
- A frequent flyer program (FFP) for customer profiles
- A yield management system (YM) to match customers with service offerings

Today, with the wealth of consumer data from smartphones and social media, two additional systems will be required, particularly considering the anticipated data glut from 5G and IoT technology. Such new systems include:

- A *data exchange* to pool data, and enrich customer and service profiles
- A *data factory* to economize on data refinement and compliance management

Pioneers have already launched into this future. Airlines themselves are evolving systems capabilities to enrich profiles with *"social media sentiment analysis, shopping queries, stated preferences versus actual behavior*" (Sabre 2015, Fig. 4, p. 11) and other "*attribute-level*" data in order to expand personalization into "*ancillary purchases*" of cabin class upgrades, preferred seating with extra leg room, fast-track security screening, onboard food and beverage, in-flight Wi-Fi, lounge access, etc. (McKinsey 2017).

Leading mobility and travel companies are creating the systems required for these personalized (1-to-1) services bundles. Uber has built "*proprietary marketplace [...] technologies [... that] include demand prediction, matching and dispatching, and pricing*" (Uber 2019, p. 162). TUI, the world's largest travel and tourism company, is building its own yield management system (YM) to personalize its hotel offers. According to its CEO, Fritz Joussen, "*first tests have shown that 30 percent of customers are willing to pay five to ten euros more per night for their preferred room*" (Manager Magazin 2019, p. 68). TUI even plans to offer its new YM capabilities as a global platform service to third parties.

In closing and to highlight the YM trend as well as to link back to the "*what data could learn from food*" analogy used earlier for the data factory, McDonald's, the iconic fast-food pioneer, "*in its largest acquisition in 20 years*" (Patton 2019), has purchased Dynamic Yield, a YM company (Bloomberg 2019). So, mobility companies can benefit from a proven blueprint that decomposes the complexity of automating the shift toward revenue per trip into a manageable set of system modules.

References

Belmonte, N.G. 2015. The Pulse of a City: How People Move Using Uber Engineering. Uber Engineering (August 18), https://eng.uber.com/pulse-of-a-city/

Bloomberg. 2019. McDonald's to Acquire Dynamic Yield, Will Use Decision Technology to Increase Personalization and Improve Customer Experience (March 25), link

BMWi, Federal Ministry for Economic Affairs and Energy. 2019. Project GAIA-X: A Federated Data Infrastructure as the Cradle of a Vibrant European Ecosystem. October, link

Carrier, E., and T. Fiig. 2018. Special Issue: Future of Airline Revenue Management. Journal of Revenue and Pricing Management (April) 17/2, https://link.springer.com/journal/41272/17/2/page/1

Crosby, L., and C. Schlueter Langdon. 2019. Data as a Product to be Managed. Marketing News, American Marketing Association (April), https://www.ama.org/marketing-news/data-is-a-product/

Crosby, L., and C. Schlueter Langdon. 2017. Why Marketers Must Keep Pace with Smart Technology. Marketing News, American Marketing Association (November), https://www.ama.org/marketing-news/why-marketers-must-keep-pace-with-smart-technology/

Crosby, L., and C. Schlueter Langdon. 2014. Technology Personified. Marketing News, American Marketing Association (February), 18-19

Dezember, R. 2018. Your Smartphone's Location Data Is Worth Big Money to Wall Street. The Wall Street Journal (November 2)

Drucker, P. 1963. Managing for Business Effectiveness. Harvard Business Review (May), https://hbr.org/1963/05/managing-for-business-effectiveness

Drucker, P. 1954. The Practice of Management. Reissue edition, October 3, 2006, Harper Business: New York, NY

Guynn, J. 2013. Nextdoor raises $60 million from Kleiner Perkins, Tiger Global. Los Angeles Times (October 29), link

Fraunhofer. 2019. Hanover Trade Fair 2019, 'International Data Space' Architecture implemented in first digital ecosystems. Fraunhofer Institute for Software and Systems Engineering, Press Release (2019-04-01), link

IDSA. 2018a. Sharing Data While Keeping Data Ownership, The Potential of IDS for the Data Economy. International Data Spaces Association, White Paper (October), link

IDSA. 2018b. Jointly Paving the Way for a Data Driven Digitisation of European Industry. International Data Spaces Association, White Paper Version 1.0 (October), https://www.internationaldataspaces.org/publications/strategic-paper-for-europe-idsa/

Jarke, M., B. Otto, and S. Ram. 2019. Data Sovereignty and Data Space Ecosystems. Business & Information System Engineering, Special Issue 61 (August): 549–550 (link)

Kahn, E. 2007. Airline Deregulation. In: Henderson D.A. (ed.). The Concise Encyclopedia of Economics (CEE) (2nd edition), https://www.econlib.org/library/Enc1/AirlineDeregulation.html

Kempf, M, and R. Ziffling. 2020. Beyond Electric – How Tesla Could Become the Apple of Automated Driving. Berylls Insights (April), Berylls Strategy Advisors, Munich

Manager Magazin. 2019. Wir verändern uns dramatisch – Interview mit TUI CEO Fritz Joussen (Mai), 67-69

McGill, J.I., and G.J. Van Ryzin. 1999. Revenue management: research overview and prospects. Transportation Science (33/2) (May): 233-256.

McKinsey & Company. 2017. How airlines can gain competitive edge through pricing (December), https://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/how-airlines-can-gain-a-competitive-edge-through-pricing

Melendez, S. 2019. A landmark Vermont law nudges over 120 data brokers out of the shadows. Fast Company (2019-02-03), link

Moore, J. F. 1996. The Death of Competition. HarperCollins: New York, NY

Moore, J. F. 1993. Predators and prey: A new ecology of competition. Harvard Business Review (May–June): 75–86.

Otto, B., D. Lis, J. Juerjens, J. Cirullies, S. Opriel, F. Howar, S. Meister, M. Spiekermann, H. Pettenpohl, and F. Möller. 2019a. Data Ecosystems: Conceptual Foundations, Constituents and Recommendations for Action. Fraunhofer ISST Report, ISSN 0943-1624 (October), Dortmund

Otto, B., S. Steinbuß, A. Teuscher, and S. Lohmann. 2019b. Reference Architecture Model Version 3.0. International Data Spaces Association (April), Dortmund

Otto, B., J. Juerjens, J. Schon, S. Auer, N. Menz, S. Wenzel, and J. Cirullies. 2016. Industrial Data Space - Digital Sovereignty Over Data. Fraunhofer Society for the Advancement of Applied Research (Working Paper), link

Otto, B. 2011. Organizing data governance: Findings from the telecommunications industry and consequences for large service providers. Communications of the AIS 29(1): 45-66

Palmer, M. 2006. Data is the New Oil. ANA Marketing Maestros (November 3), https://ana.blogs.com/maestros/2006/11/data_is_the_new.html

Patton, L. 2019. McDonald's $300 Million Tech Deal Will Revolutionize Menus. Bloomberg (March 25), link

Porter, M. E., and J. E. Heppelmann. 2015. How Smart, Connected Products Are Transforming Companies. Harvard Business Review (October): 96-114, https://hbr.org/2015/10/how-smart-connected-products-are-transforming-companies

Press, G. 2016. Cleaning Big Data: Most Time-Consuming, Least Enjoyable Data Science Task, Survey Says. Forbes (2016-03-23)

Sabre. 2015. The Evolution of Customer Data – How data driven personalization will change the game for airlines. White Paper, Texas (June 1), https://www.sabre.com/insights/the-evolution-of-customer-data/

Schlueter Langdon, C. 2019. One Future of Auto is Airlines – Yield Management Systems to the Rescue. Working Paper (WP_DCL-Drucker-CGU_2019-08), Customer Lab, Peter Drucker School of Management, Claremont Graduate University, https://research.cgu.edu/drucker-customer-lab/auto-3/

Schlueter Langdon, C. 2006. Designing Information Systems Capabilities to Create Business Value: A Theoretical Conceptualization of the Role of Flexibility and Integration. Journal of Database Management 17(3) (July-September): 1-18

Schlueter Langdon, C. 2003a. The State of Web Services. IEEE Computer 36(7): 93-95

Schlueter Langdon, C. 2003b. Information Systems Architecture Styles and Business Interaction Patterns: Toward Theoretic Correspondence. Journal of Information Systems and E-Business 1(3): 283-304

Schlueter Langdon, C. 2003c. Does IT Matter? An HBR Debate. Harvard Business Review (April), http://www.johnseelybrown.com/Web_Letters.pdf

Schlueter Langdon, C., and R. Sikora. 2020. Creating a Data Factory for Data Products. In: Lang, K.R., J.J. Xu et al. (eds). Smart Business: Technology and Data Enabled Innovative Business Models and Practices. Springer Nature, Switzerland, https://link.springer.com/chapter/10.1007/978-3-030-67781-7_5

Smith, B.C., J.F. Leimkuhler, and R.M. Darrow. 1992. Yield Management at American Airlines. Journal on Applied Analytics (22/1), https://pubsonline.informs.org/doi/pdf/10.1287/inte.22.1.8

Stephens, L., D. Fuller, N. Boivin, T. Rick, N. Gauthier, A. Kay, B. Marwick, Ben; C.G. Armstrong; C.M. Barton. 2019. Archaeological assessment reveals Earth's early transformation through land use. Science 365 (6456): 897–902

Tsujimoto, M., Y. Kajikawa, J. Tomita, and Y. Matsumoto. 2018. A review of the ecosystem concept - Towards coherent ecosystem design. Technological Forecasting and Social Change, Volume 136 (November): 49-58

Uber Technologies, Inc. 2019. 2019 Form S-1 Registration Statement (April 26). https://www.sec.gov/Archives/edgar/

US Food & Drug Administration. 2016. Changes to the Nutrition Facts Label (May 27). https://www.fda.gov/food/food-labeling-nutrition/changes-nutrition-facts-label

Vermont Office of the Attorney General. 2018. Guidance on Vermont's Act 171 of 2018 Data

Broker Regulation (2018-12-11), https://ago.vermont.gov/wp-content/uploads/2018/12/2018-12-11-VT-Data-Broker-Regulation-Guidance.pdf

Vollenweider, M. 2016. Mind+Machine: A Decision Model for Optimization and Implementing Analytics. John Wiley & Sons: Hoboken, NJ

3 Pan-European perspective

By Harrie Bastiaansen, Ruud Mollema and Anant Vikram

Context

A few developments:

- Data sharing infrastructures/data spaces based on (European) IDS architecture provide an attractive initiative providing standardized concepts and technologies for providing data sovereignty and security, whilst aiming for interoperability.
- The logistics and transport sector are relevant business sectors for Europe with international characteristics and a requirement for data collaboration which guarantees the flow of goods and lowers our carbon footprint.
- The IDS concepts and technology and its importance for/relevance for IoT may provide business opportunities for the roll-out of 5G. The future positioning of telecommunications companies as providers of the 'basic data sharing infrastructures' in which data sharing features are embedded as part of the basic telecommunications infrastructure (5G).

3.1 Data-sharing policy making and development initiatives

Ideally, data should be broadly accessible, but the reality is very different. Data is valuable and stakeholders have different (potentially conflicting) goals and needs. Therefore, concerns regarding the misuse of shared data due to a lack of control (data sovereignty, trust, and security) hinder large-scale data sharing. There are potential costs involved in supplying the data. In addition, there are regulatory restrictions which may be applicable when it comes to data sharing, such as the General Data Protection Regulation (GDPR).

These concerns pose barriers to data sharing, despite the potential benefits of data sharing on a larger scale. This is not only the case for mobility – a common need for improved data sharing has been recognized across various sectors of society. This has led to a multitude of (inter-)national developments in data-sharing policy making and development initiatives.

3.1.1 The EU's position on data sharing

The importance of data sharing is well recognized by the EU. In response to the European Commission Communication, the BDVA released a white paper identifying the key technical challenges for data sharing from a user's perspective:

"To realize a cross-border, cross-sectoral sharing data space and enable platforms to process 'mixed' proprietary, personal and open public data introduces new technical challenges."

The European Commission has published a communication on the European data strategy [3], building on the importance of (big) data sharing under European values (such as data sovereignty and privacy) for the stimulation and support of AI in Europe.

3.1.2 Dutch initiatives on data sharing

The Dutch Ministry of Economic Affairs and Climate has published various policy documents on the topic of sharing data within and between economic sectors, outlining the economic value of data sharing and the importance of an adequate data sharing environment as a key enabler.

A set of nine essential building blocks has been identified for data sharing initiatives to support the emerging data economy. While organizations are realizing the importance of data sovereignty more and more, these building blocks enable them to be in control of utilizing and benefitting from the potential value of their data. The building blocks are listed in Figure 1.

Currently, various Dutch data-sharing 'communities-of-practice' are actively defining an aligned data-sharing approach over various sectors.

- *Dutch Data Sharing Coalition* (DDSC): The ambition of DDSC is to push the evolution in the direction of cross-sectoral data sharing. This means not only enabling data sharing between a few organizations for a specific application, but rather aiming for a generic data-sharing environment.
- *'Data Sharing' working group (WG) of the Dutch AI Coalition (NL AIC)*: Realizing that artificial intelligence (AI) will have an impact on all business sectors, our private lives, and society, NL AIC was founded as the catalyst for AI applications in the Netherlands. NL AIC has identified data sharing as one of its five cross-sector key enablers for improving the position of the Netherlands. This is a logical conclusion: many AI applications need data to be trained, improved, and to execute AI algorithms.

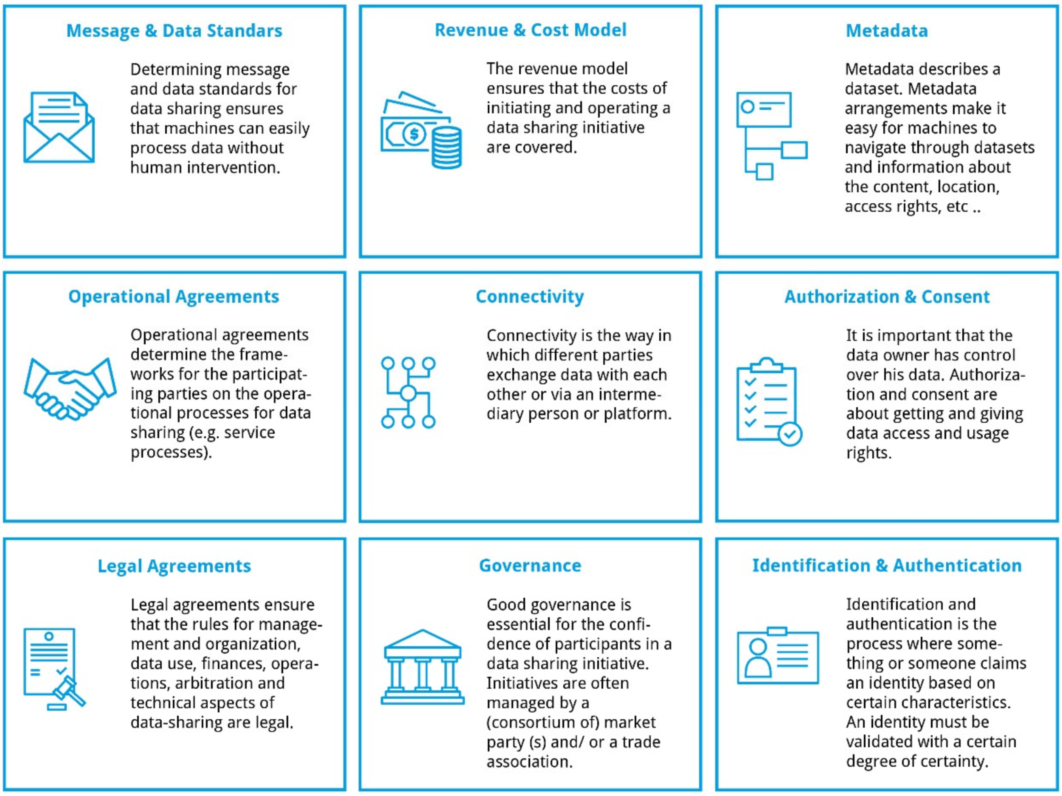

Figure 1: Essential building blocks as the basis for responsible data sharing.

3.1.3 Development perspective: functional levels and architectural approaches

In (moving towards) a network-model approach, various levels of functionality may be distinguished as illustrated in Figure 2.

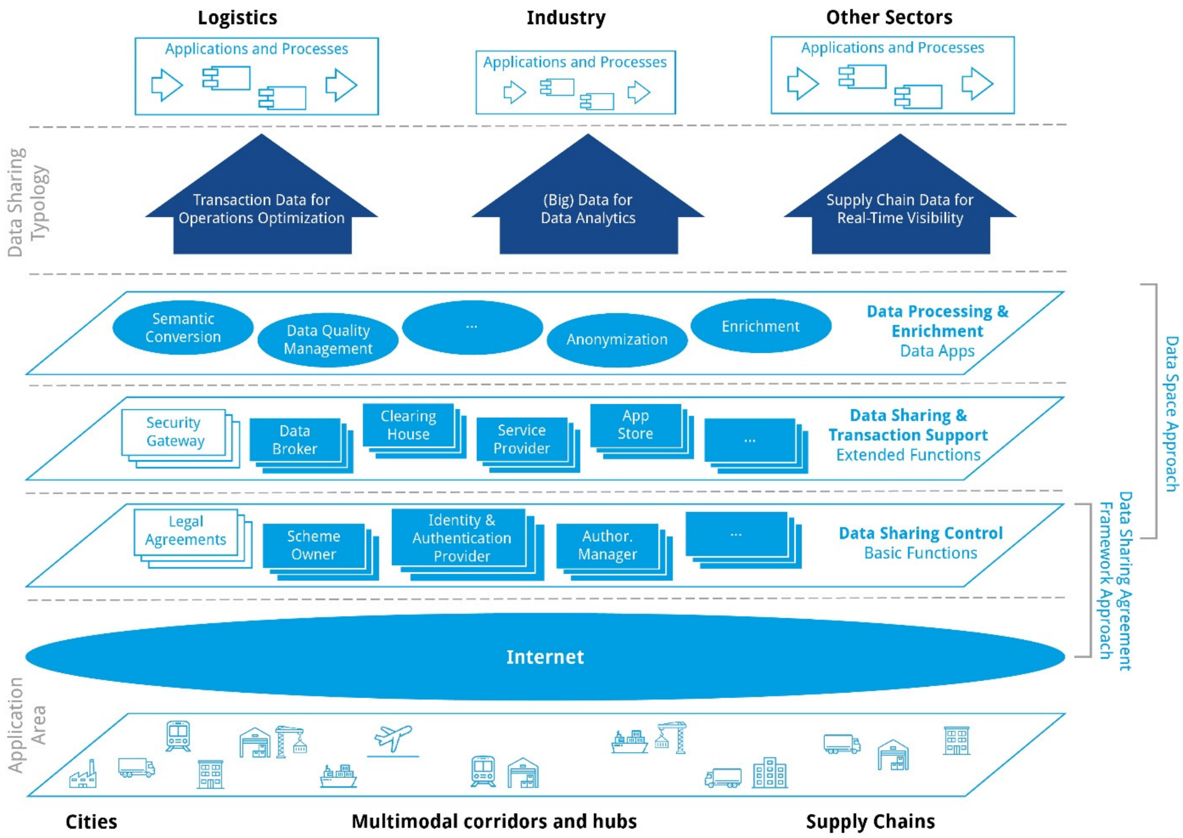

Figure 2: Functional levels with generic services (building blocks) in a logistics data sharing ecosystem.

As Figure 2 depicts, there are three levels of functionality that can be distinguished, each with a set of generic services (building blocks) that are made available in data sharing for logistics [10]. These are also applicable in other ecosystems:

- **Data-sharing control services**
  These provide the basic functions as required in a data-sharing infrastructure providing data sovereignty and security. It includes a joint legal data sharing agreement service to be agreed upon between data providers and data consumers, a scheme owner managing the subscribed organization, identity and authentication providers, and perhaps even an authorization capability for defining and enforcing usage contracts on the specific access and usage control conditions for individual data-sharing transactions.
- **Data sharing and transaction support services**
  These provide an extended set of functions to support data-sharing transactions, e.g., on registering and publishing available data resources (a 'data

broker' or service registry), on administering and logging data sharing agreements and transactions for reporting, billing, and conflict resolution (a 'clearing house'), and enforcing the data sovereignty policies thereof (e.g., security gateway functions). Such supporting functions for data-sharing transactions involve metadata which could also be sensitive and would therefore require adequate data sovereignty and security measures. In this context, it is good to refer to the FAIR concept and principles, on the findability, accessibility interoperability, and reuse of data, which come from the management of scientific data but are increasingly being adopted in other sectors as well.

- **Data processing and enrichment services**
  These provide services (for instance, by means of a data app) for processing data prior to sharing or after being shared, e.g., for semantic conversions between data formats, management of the data's quality, and its pseudonymization or anonymization. Such functions may be needed to use a data space approach in complex application areas such as artificial intelligence and machine learning [14]. They may be provided by means of (a library of) data-processing data apps.

As the figure depicts, these three levels of functionality can be loosely related to two approaches which are currently attracting attention for realizing a network-model data sharing infrastructure: an agreement framework approach and a data space approach.

In an *agreement framework approach*, a joint (legal) data-sharing agreement is agreed upon between data providers and data consumers, possibly including an authorization capability for defining and enforcing usage contracts on the specific access and usage control conditions for individual data-sharing transactions. An agreement framework may be used within an ecosystem of data-sharing organizations, e.g., within the same sector.

A *data space (or data market) approach* provides value-adding functions as part of a broader system approach which includes the supporting functions for data-sharing transactions as well as for data processing and enrichment functions as depicted in the figure 2. The International Data Spaces initiative (IDS) is currently gaining major European interest as a data space approach. Value-adding functions are provided by means of a (library of) data apps which run within an IDS security gateway or IDS-connector. These allow for flexibility and extendibility of the data space functionality. Individual organizations can 'personalize' it to their individual needs. Hence, it may be thought of as a managed and secure 'data-sharing operating system', much like a mobile phone's operating system.

There is an initial IDS implementation in the Netherlands in the form of the Smart Connected Supplier Network (SCSN [18]), a field lab initiative of Brainport Industries which aims to enable improved cooperation in the supply chain of around 300 companies supporting large high-tech companies in the Eindhoven area. Another example based on similar principles but using different technology is the AMsterdam data EXchange (AMdEX, a data space initiative of the Amsterdam Economic Board for enabling local or (inter-) national collaboration on a transparent, open, data market.

3.2 Data sharing and mobility

Improving the flow of mobility with data is high on the Dutch Government's agenda. One example of this is the Beter Benutten program. In the 'Beter Benutten' ('Optimising Use') program, the Dutch government, regions, and businesses are all working together to improve road, waterway, and railway accessibility in the busiest regions. Its first aim has been to reduce congestion at the busiest points by 20 percent in 2014, using a package of around 300 practical and quantifiable measures. The aim of the follow-up program, from 2017 up to now, is to achieve 10 percent shorter journey times from door to door in the busiest areas.

3.2.1 Talking Traffic

The Partnership Talking Traffic is part of the program and is a collaboration between the Dutch Ministry of Infrastructure and Water Management, 60 regional and local authorities, and national and international private companies. These partners are working together to accelerate development and deployment with regard to retrieving and organizing traffic light data (cluster 1), to process, enrich, and distribute a wide variety of data and convert this into real-time and made-to-measure data sets and information (cluster 2), and to provide this information to a wide variety of road users (cluster 3) via their smart phones, PNDs, and in-car systems. This joint co-investment program seeks to enhance the availability of intelligent data for a wide group of road users (cars, trucks, public transport, emergency services, cyclists). In this way, the safety and sustainability of traffic and transport could be enhanced, resulting in a reduction in travel times and, eventually, lower public expenditure.

Not only do private parties cover these three clusters with their knowledge, they are also a good reflection of today's technological information society. From the knowledge and authority of, for example, one of the largest suppliers of telecommunications and ICT services, to start-ups that disrupt the market with daring ideas and fast times to market. Mixing global and local players in this partnership has helped speed up the development and deployment of new driver assistance services and lays the groundwork for the next levels in connected and automated driving, all while delivering new services from the beginning of 2018 onward.

3.2.2 Maas Pilots

MaaS-NL case:

The Dutch government started in 2019 with seven regions national MaaS pilots in The Netherlands:

These national pilots were based on a Framework Agreement with 24 consortia of MaaS Service Providers, Transport Operators and other service providers. In the framework agreement the rules of the game were set as a framework for the ecosystem that is being pursued. In the pilots the rules are implemented and tested, on program level they are discussed and evaluated. Rules are about privacy, data sharing and the use of API's and other standards. Specific in the MaaS-NL is the obligation to deliver trip/leg data to a national Learning Environment. The Dutch MaaS program works closely together with the international MaaS Alliance, the other Benelux countries and North Rhine Westphalia. One of the cornerstones in MaaS-NL is the TOMP-API that handles the digital communication between the MaaS Service Provider and it's Transport Operator in planning, booking and supporting each MaaS trip. This API is already being implemented in Switzerland as well.

The discussion about governance will be executed as soon as the effect of the rules becomes evident. In 2020 the focus is on the Dutch Data Sharing Coalition and AI-coalition, Fair and elaboration on the principles of IDS which are incorporated in MaaS-NL. Together with the consortia in the Framework agreement and other stakeholders, work is being done to design a MaaS data space on a national level, with due observance of a progression to European level. It is anticipated that the sector will take over the initial role of the government. The use of experimental space in the form of pilots, PoC's and other initiatives is crucial in this regard. The MaaS Dataspace is closely linked to the logistics dataspace e.g., in the field of base data on different levels.

3.2.3 iSHARE

The iSHARE initiative provides just this kind of framework agreement for the logistics sector in the Netherlands. It realizes a uniform series of agreements for identification, authentication, and authorization. Similar framework agreement approaches in other sectors include MedMij, a system of agreements for the exchange of health data, and Incoterms, an international standard on the rights and obligations of the buyer and seller in the international transportation of goods, developed and published by the International Chamber of Commerce (ICC). An overview of framework agreements for various sectors in the Netherlands is provided in.

The framework agreement approach and the data space approach could complement one another and provide a path for growth. They mostly pursue similar goals by realizing a network model approach with a strong focus on data sovereignty and trust in data sharing.

A main focus of the framework agreement is on the rules that are agreed upon by data sharing partners. A data space approach adds an infrastructural layer with more advanced features for data-sharing support as well as extending its functionality, while still requiring a firm grounding in legal agreements.

However, regardless of how both approaches complement one another, their actual interoperability also depends on the architecture and implementation choices that have been made in both approaches. The choices on data sovereignty (access and usage) policies and their supporting authorization protocols will particularly impact the level of interoperability and ease of migration. In addition, specific attention is needed for hybrid situations in which a data provider and data consumer are using different approaches. A strategy is required for handling such hybrid situations to ensure interoperability and easy migration for end users between these data-sharing approaches.

These considerations also apply to the iSHARE agreement framework initiative as developed by the logistics sector in the Netherlands (and are currently being deployed and extended to other sectors as well as internationally) and the IDS as an emerging European data space approach. Both iSHARE and IDS have recognized the potential in aligning with one another and striving for an interoperable and complementary approach in which the strengths of both initiatives are reinforced by each other. This has resulted in a recent agreement to align the iSHARE and the IDS initiatives 0. The goal is to provide (logistics) organizations with a well-defined evolution path in which iSHARE provides an easy onboarding process with low barriers to participation as part of the growth path towards a more extensive data space approach.

As the development of both framework agreement and data space approaches are developing in the logistics sector and beyond, the definition of an adequate roadmap, architecture, and implementation choices is opportune. This will prevent complex migration trajectories on a long-term basis.

The focus of the development perspective on data sharing functional levels and architecture as described in this section has been on the data-sharing infrastructure within the logistics sector or ecosystem. The broader perspective of cross-sector and cross-border data sharing is addressed in the following paragraph.

3.3 A cross-sector and cross-border perspective: the interoperability challenge

It is important to realize that the scope of logistics goes far beyond the boundaries of its own sector. The logistics sector is closely connected to other sectors, such as mobility. Moreover, it also has a major international component. This implies that a logistics data-driven and data-sharing infrastructure strategy and roadmap should be firmly embedded in and aligned with the developments and approaches taken in other sectors and countries. It will help in preventing complex and costly migrations in the future. This specifically applies to determining its cross-sector strategy in developing and adopting a (combination of an) framework agreement approach and data space approach.

The preference is evidently for an aligned definition and adoption of the same data-sharing infrastructure approach within and across sectors. Nevertheless, this will show to be unrealistic in practice. A multitude of separate data-sharing ecosystems, realized with their own specific implementation choices, is likely to emerge. Various initiatives for both the framework agreement approach and the data space approach are being developed and deployed within various sectors of society. As data sharing should not be limited to a specific sector, interoperability of these initiatives is of great importance.

Interoperability between separate data sharing ecosystems is complex, however, as it spans a variety of aspects and perspectives which must be considered concerning data and schemes of operation. This complexity is represented by the new European Interoperability Framework as developed by the European Commission. It provides guidance for meeting interoperability challenges. As Figure 3 shows, it identifies four levels at which interoperability must be realized under an overarching integrated governance approach: legal, organizational, semantic, and technical interoperability.

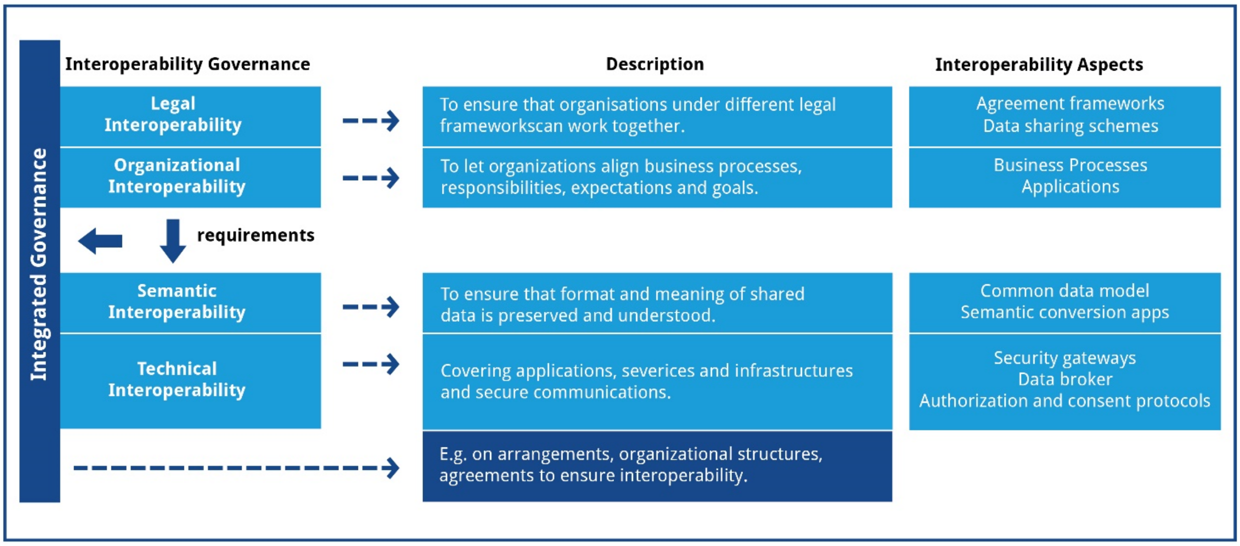

Figure 3: The new European Interoperability Framework.

The right column in the figure 3 shows the relevant aspects for each of the four interoperability levels at which interoperability between data sharing approaches has to be taken care of. These aspects reflect the components in the federative data-sharing infrastructure as depicted in Special attention is needed for the complex topic of interoperability of agreements between organizations active in different data-sharing environments under various legal jurisdictions. This may require an approach that will enable negotiations on data-sharing agreements between organizations. This aspect of negotiating data-sharing agreements is mentioned, for example, in the reference architecture of the International Data Spaces (IDS) initiative, without currently giving concrete details of how this will be designed. A precondition for this is a formal semantic foundation that ensures that organizations unambiguously understand each other.

3.4 How can scaling be carried out?

Since local initiatives are a logical scope to start with, scaling across borders, within Europe at the very least, is a requirement for success. How can we make sure that we can easily expand a proven local scope to other countries in Europe?

The introduction of 5G will particularly help establish the Internet of Things (IoT). 5G promises a more IoT-friendly ecosystem, with vast improvements over the current capabilities of 4G. Not only will it allow extremely fast data speeds, 5G also means latency of just 1 millisecond. Compared to 4G LTE, it will be able to embrace up to 100 times more connected devices per unit area.

Positioning IDS in relation to/to complement 5G data-sharing features might provide benefits for both the IDS and introduction of 5G and reinforce each other's potential. IDS and its data-sharing feature on trust, data sovereignty, and security may potentially offer KPN value-added services in the IoT domain for the 5G infrastructure (especially when aligning them with the KPN data service portfolio, e.g., the KPN Data Services Hub). Vice versa, an IDS-based service implementation tailored to and aligned with the 5G infrastructure and service features may lower its barriers for large scale adoption. Hence, the strategic interest for KPN is in a combined and optimized service offering of IDS and 5G for the IoT and data-sharing business market. Augmenting the 5G roll-out with embedded IDS features may strengthen both their business potential.

The combination of developments sketched above may lead to new business opportunities for telecommunications companies. There is therefore value foreseen in exploring the various developments on DIH, DSH, 5G, and IDS in the international context, e.g., for supporting a cross-border logistics corridor from the Netherlands to Germany.

The basis for such a business opportunity is formed by interoperability of the data sharing infrastructures between these countries at various (stacked) levels:

- Between IDS and 5G
- Between IDS and logistics-supporting processes and use cases
- Between operators (KPN and Deutsche Telekom) at various levels: IDS, 5G and

KPN DSH and DT Data Intelligence Hub (DIH).
- IDS is part of the execution program as a potential data-sharing approach, linked to the Top Sector Logistics Action Agenda 2021 – 2023
- An IDS innovation program is planned for the period 2021 - 2022

Regarding the business opportunity outlined above, the TKI Dialog IDS project addresses the following research and innovation topics:

- How does IDS, with its features and architecture on data sovereignty, trust, and security, align with/complement the 5G architecture, especially in terms of supporting of IoT data sharing and edge computing within a 5G infrastructure?
- What is the status/are the issues when exploring the combined developments on KPN DSH, 5G, and IDS in an international EU context?
- How does IDS and its features align with the federated architecture and approach for enabling EU-wide logistics capabilities?

3.5 Summary

Summarize main points of the chapter : European developed ideas to data sharing in logistics, mobility, similar approach, common use cases, telcos are already working on the concept, have the right infra and services setup in place to create ecosystems, enable creation of testbeds etc. so ecosystem partners can work together to solve common problems in data sharing: refer to Fenix use case for logistics, Europe is getting more proactive in finding solutions that enable cross-border data sharing in logistics and mobility. Enabler in this context are architectural standardization associations (e.g., IDS), potential ecosystem members that are working on similar solutions or have similar problems (e.g., The logistics and mobility industry) to solve and telecommunication infrastructure providers (e.g. KPN and DTAG). Developing European ecosystems that fulfill all the regulations of the IDS Reference Architecture and thus enable a fast/scalable (5G) and secure (IDS) exchange of data between various industries will be a big step towards common European data spaces. According to the IDS Reference Architecture these ecosystems will then combine all the necessary roles (e.g., data providers, app providers, broker service providers) that enable a self-contained and independent functionality. Companies across Europe are becoming more and more eager to join existing ecosystems and data-exchange-platforms. An example may be the German lamp producer FENIX who joined the IDS-certified Deutsche Telekom Data Intelligence Hub (DIH) in 2020. Joining the DIH ecosystem now enables FENIX to combine and evaluate the data of its European logistics actors in a fast, secure and scalable way.

3.6 Profiles

T-Systems profile

With a footprint in over 30 countries, 38,000 employees, and revenue of 6.8 billion euros (2019), T-Systems is one of the world's leading providers of digital services headquartered in Europe. T-Systems partners up with its clients as they successfully navigate their digital transformation. The company offers integrated solutions for enterprise clients, serving every DAX 30 company in Germany and 100 of the Top Fortune 500 companies globally. These organizations all use T-Systems' services to run mission-critical applications. Without the ICT provided by T-Systems, these clients would not be able to run their businesses. As a Deutsche Telekom subsidiary, T-Systems is a one-stop shop: from the secure operation of legacy systems and classical ICT services, and the transition to cloud-based services (including international networks, tailored infrastructure, platforms, and software), as well as new business models and innovation projects in the Internet of Things.

KPN profile

KPN is a leading telecommunications and IT provider and market leader in the Netherlands. With our fixed and mobile networks for telephony, data, and television, we serve customers at home and abroad. KPN focuses on both private customers and business users, from small to large. In addition, we offer telecommunications providers with access to our widespread networks.

KPN is a founding partner of the innovation Partnership Talking Traffic and the Dutch Data Sharing Coalition. KPN founded the 5G Mobility Field Lab in Helmond to explore the new opportunities of this technology in the mobility and logistics sector.

TNO profile

The Netherlands Organization for Applied Scientific Research (TNO) is an independent research organization. We connect people and knowledge to create innovations that boost the sustainable competitive strength of industry and well-being of society. Now and in the future. This is our mission, and it is what drives us, the over 3.000 professionals at TNO, in our work every day. We work in collaboration with partners and focus on transitions or changes in nine social themes that we have identified together with our stakeholders.

TNO fulfills the role of regional IDS hub in the Netherlands within the IDS Association (IDSA). As such, TNO is the IDSA knowledge partner in the Netherlands. TNO has in-depth theoretical and hands-on knowledge of IDS and is doing various research and innovation projects in the area of trusted data sharing and IDS.

MaaS program

The MaaS program is run by the Dutch Department of Infrastructure and Water Management in cooperation with seven regions. The program facilitates seven national pilots with 23 MaaS Consortia, which are selected in a tender under a framework agreement.

References

Amsterdam Economic Board. "Amsterdam Data Exchange". URL: https://www.amsterdameconomicboard.com/initiatief/amdex.

Bastiaansen H.J.M., Nieuwenhuis K, TKI Dinalog e.a. (2020) "The Logistics Data Sharing Infrastructure - White Paper". URL: https://www.dinalog.nl/wp-content/uploads/2020/08/Dinalog_Whitepaper-Data-Infrastructure_DEF.pdf.

Bastiaansen, H.J.M., Dalmolen, S., Kollenstart, M. and T. van Engers (2020). "User-Centric Network-Model for Data Control with Interoperable Legal Data Sharing Artefacts - Improved Data Sovereignty, Trust and Security for Enhanced Adoption in Interorganizational and Supply Chain IS Applications". Twenty-Fourth Pacific Asia Conference on Information Systems, Dubai, UAE, June 2020. URL: https://aisel.aisnet.org/pacis2020/172/.

Big Data Value Association (2019). "Towards a European data sharing space". URL: https://www.eoscsecretariat.eu/towards-european-data-sharing-space.

Brainport Industry Campus (BIC) Eindhoven. "Smart Connected Supplier Network (SCSN)". URL: https://smartindustry.nl/fieldlabs/8-smart-connected-supplier-network/.

Dalmolen, S., Bastiaansen, H.J.M., Kollenstart, M. and M. Punter (2019). "Infrastructural Sovereignty over Agreement and Transaction Data ('Metadata') in an Open Network-Model for Multilateral Sharing of Sensitive Data". International Conference on Information Systems (ICIS) 2019, Munich, Germany, 15th – 18th December 2019. URL: https://aisel.aisnet.org/icis2019/economics_is/economics_is/23/.

Data Sharing Coalition. URL: https://datasharingcoalition.eu/about/.

Dutch Ministry of Infrastructure and Water Management. "MaaS-pilots - Optimaliseren van het mobiliteitssysteem". URL: https://www.rijksoverheid.nl/onderwerpen/mobiliteit-nu-en-in-de-toekomst/documenten/brochures/2019/05/31/maas-pilots---optimaliseren-van-het-mobiliteitssysteem.

Dutch Neutral Logistics Information Platform. "iSHARE Data Sharing Initiative". URL: https://www.iSHAREworks.org/en/.

Dutch AI Coalition (NL AIC) Working Group Data Sharing (2020). "Responsible data sharing for AI”. URL: https://nlaic.com/themas/data-delen/.

Dutch Ministry of Economic Affairs and Climate Policy (2018). “Nederlandse Digitaliseringsstrategie”. URL: https://www.nederlanddigitaal.nl/nederlandse-digitaliseringsstrategie/documenten/publicaties/2018/6/1/publicatie-nederlandse-digitaliseringsstrategie.

Dutch Ministry of Economic Affairs and Climate Policy, ‘Generiek afsprakenstelsel voor datadeelinitiatieven als basis van de digitale economie’, 2018. URL: https://www.rijksoverheid.nl/documenten/rapporten/2018/ 12/30/generiek-afsprakenstelsel-voor-datadeelinitiatieven-als-basis-van-de-digitale-economie.

Dutch Ministry of Economic Affairs and Climate Policy: ‘Nederland Digitaal - De Nederlandse visie op datadeling tussen bedrijven’, 2019. URL: https://www.rijksoverheid.nl/documenten/publicaties/2019/02/20/nederland-digitaal---de-nederlandse-visie-op-datadeling-tussen-bedrijven.

European Commission (2017). “New European Interoperability Framework (EIF) – Promoting seamless services and data flows for European public administrations”. European Union: Brussels, 2017. URL: https://ec.europa.eu/isa2/sites/isa/files/eif_brochure_final.pdf.

European Commission (2018). “Towards a common European data space”. URL: https://ec.europa.eu/digital-single-market/en/news/communication-towards-common-european-data-space.

European Commission (2018). “Coordinated Plan on AI”. EC Communications 795. URL: https://ec.europa.eu/digital-single-market/en/news/coordinated-plan-artificial-intelligence.

European Commission (2018). “Artificial Intelligence for Europe”. EC Communications 237. URL: https://ec.europa.eu/transparency/regdoc/rep/1/2018/en/com-2018-237-f1-en-main-part-1.pdf.

European Commission (2020). “A European strategy for data”. EC Communications 66. URL: https://ec.europa.eu/digital-single-market/en/policies/building-european-data-economy.

European Commission (2020). “On Artificial Intelligence - A European approach to excellence and trust”. EC Communications 65. URL: https://ec.europa.eu/info/publications/white-paper-artificial-intelligence-european-approach-excellence-and-trust_en.

Go-Fair. “FAIR Prinicples”. URL: https://www.go-fair.org/fair-principles/.

IDSA. “International Data Spaces’. URL: https://www.internationaldataspaces.org/.

IDSA (2019). “IDSA and iSHARE join forces to achieve data sovereignty”. URL:

https://www.internationaldataspaces.org/idsa-and-ishare-join-forces-to-achieve-data-sovereignty/.

MedMij. "Afsprakenstelsel voor het uitwisselen van gezondheidsgegevens tussen zorgprofessionals en zorggebruikers". URL: https://www.medmij.nl/afsprakenstelsel/.

NL AIC - Dutch AI Coalition Working Group Data Sharing (2020). "Responsible data sharing for AI". URL: https://nlaic.com/themas/data-delen/

Otto, B., Steinbuss, S., Teuscher, A. and S. Lohmann (2019). "International Data Spaces: Reference Architecture Model Version 3". URL: https://www.internationaldataspaces.org/wp-content/uploads/2019/03/IDS-Reference-Architecture-Model-3.0.pdf (visited on 29/11/2019).

4 Mobility Data Space

Sebastian Pretzsch, Holger Drees, Dr. Lutz Rittershaus

4.1 Summary

To successfully support decision making or even automatically make decisions of their own, intelligent transport and mobility systems require large amounts of data. Although multitudes of mobility data are already being collected today, the comprehensive processing and exploitation of this data has often been impossible due to technical, legal or economic reasons. With Mobility Data Space, an open data space is now being created which offers access to real-time traffic data and sensitive mobility data beyond their secure exchange, and which links existing data platforms to each other. In the future, it will thus be possible to provide comprehensive mobility data on a national level.

Based on a decentralized system architecture developed by the International Data Spaces Association e. V., the Mobility Data Space offers an ecosystem in which data providers can specify and control the conditions under which their data can be used by third parties. This approach creates data sovereignty as well as trust, and data users can be sure about data origin and quality. By integrating data from the public and private sector via regional and national platforms, the Mobility Data Space will become a digital distribution channel for data-driven business models, providing entirely new options of data acquisition, linking and exploitation.

Whether data provider, user, developer or end user – the Mobility Data Space takes all acting parties into consideration and offers:

- Data sovereignty and security along the value chain,
- Standardized access to data from both public and private sources,
- Space for the emergence of new business models,
- distribution channels and services, as well as
- A larger selection of innovative mobility services and applications.

International Data Space

The International Data Spaces (IDS, until 2019 known as »Industrial Data Space«) was designed by the Fraunhofer-Gesellschaft in 2015 with the aim of creating a safe data space for the sovereign management of data assets by enterprises from different fields. Due to the overwhelming feedback to the industry initiative, the International Data Spaces Association e. V. was founded in 2016. It is continuing the development of the International Data Spaces reference architecture and supports the industry in its introduction and implementation.

Fraunhofer coordinates the adaptation of the IDS reference architecture to sector-specific needs through IDS verticalization. The Fraunhofer IVI leads the Mobility Data Space verticalization initiative, supporting the transportation and mobility sector in creating new mobility services using data-based business models in sovereign data ecosystems.

4.2 Mobility data – the status quo

Collecting mobility data is increasingly gaining in importance. It is the only way in which intelligent systems can provide traffic participants and decision makers with sufficient information to optimize traffic flows, increase safety and protect the environment.

The interaction of several different traffic participants, providers and operators requires a trustworthy exchange of data and their interoperability.

In the field of mobility, quite a large amount of data requires protection. Among these are data on traffic infrastructure and real-time data on the current traffic situation. Data from different sources need to be merged either physically or virtually at the point of decision.

Data acquired by the German Federal Government and the Federal States are already being provided to users in a standardized format in the Mobilitäts Daten Marktplatz (MDM, Mobility Data Marketplace) of the Federal Ministry of Transport and Digital Infrastructure (BMVI).

On a regional level, this data is partly available via corresponding platforms. The fact that the data is rarely ever provided in a national context complicates its multi-regional exploitation.

Public transport providers, car sharing providers and charging station operators are usually reluctant to provide further mobility data to third parties. Reasons for this include the lack of infrastructure (i. e. a National Access Point for data exchange) and the lack of established data formats and interfaces, which as of yet do not apply in certain sectors (car sharing, bike sharing, e-mobility).

Sensitive data, such as passenger flows, which is generated by vehicles or privately owned mobile devices, is being collected and processed by public transport providers, navigation service providers, fleet operators and mobile communications providers. However, there is virtually no cross-company utilization, processing and linking of this data due to its sensitivity in terms of data protection, informational autonomy and protection of trade secrets.

4.2.1 Security and sovereignty for new exploitation options

The Mobility Data Space offers a solution: an open mobility data ecosystem in which data providers can specify and control the conditions under which their data may be used and exploited by third parties. This approach creates data sovereignty and a trusting environment for data providers, and it gives data users assurance about data origin and quality.

Through the assurance of data sovereignty, data that had previously not been usable due to its sensitive nature can now be exploited. The mobility data space will become a digital distribution channel for data-driven business models. The linking of public and private data via regional and national data platforms through a decentralized data space concept provides completely new options for data acquisition, linking and utilization.

Within the scope of a collaboration between the Fraunhofer-Gesellschaft and ca. 100 enterprises, the International Data Space (IDS) was created as a basis for decentralized data value chains. Ever since its inception, the IDS has been continuously improved by the International Data Spaces Association e. V. For a better combination of resources, the future will see the integration of cloud infrastructures into data spaces and their interlinking through projects such as GAIA-X.

4.3 The Mobility Data Space: architecture and components

Beyond the IDS‘ technical functionalities in the area of secure and sovereign data exchange, the Mobility Data Space aims at making accessible real-time traffic data (e. g., sensor data, traffic light sequences) and sensitive mobility data (e. g., vehicle-generated and smartphone-generated data, movement patterns) as well as connecting local, regional and national data platforms in order to facilitate the provision of comprehensive mobility data on a national level. Services and applications for data enhancement and exploitation form the basis for a broad mobility data ecosystem.

The Mobility Data Space

- is based on the open, decentralized system architecture developed by the International Data Spaces Association e. V.,
- guarantees data providers sovereignty over their own data and security along

the processing and value chains in the sense of a digital rights management system,
- allows the provision and distribution of sensitive data, as well as the traceability of their use for purposes of billing/payment,
- provides data users (e. g., travel information services) with standardized access to an ecosystem that pools data from public and private sources and services through the connecting of local, regional and national platforms,
- opens up new business opportunities
- for developers: data apps for mobility services and applications, including distribution via a data app store
- for IT service providers: hosting of components and data apps in cloud environments as well as corresponding consulting services,
- offers advantages for end users by fostering the development of novel mobility applications and services through the availability of mobility data sources.

4.3.1 Data sovereignty through usage control

Participation in a secure data space is possible via a technical connector component that data providers and data users either host themselves or have hosted for them. The data space is established across the networked connectors, meaning that it is not a centralized platform but rather an expandable network of decentralized players (minimum of two). Before being transferred to the target connector, the data to be provided is extended by a set of rules, the so-called »usage policy«. The data remains in the target connector and is secure against direct access by the data user. If data users want to work with the data, e. g., for purposes of data analysis or fusion, they must access it within the connector via so-called »data apps«.

These apps are capable of integrating further data, e. g., from user databases that are run outside of the connector. A usage control layer within the connector guarantees compliance of the data app with the specified rules, with the effect that only aggregated results will leave the connector. All steps taken during data use and processing within the data space can be recorded. This way, data providers have complete knowledge of all activities relating to their data.

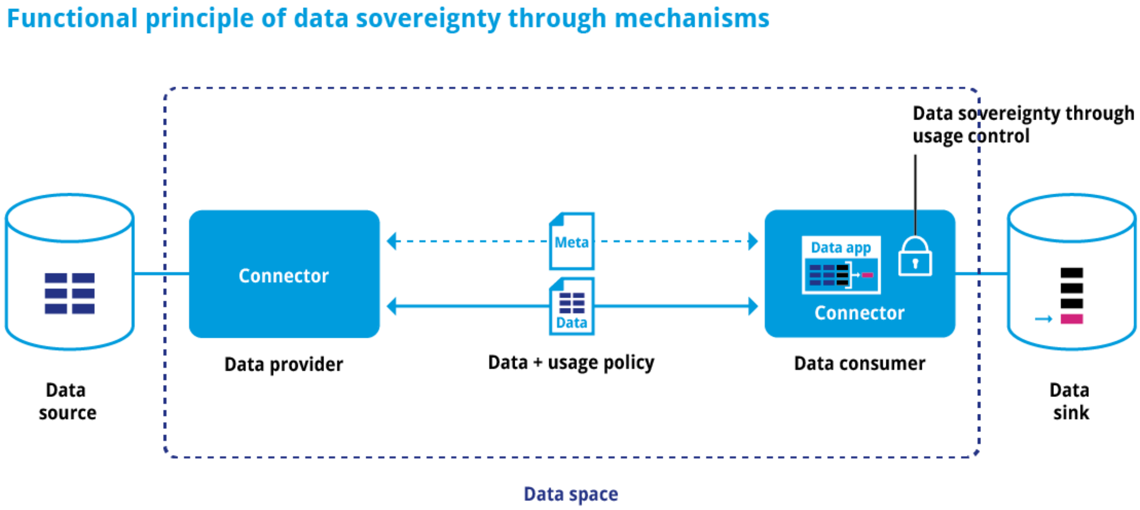

Figure 1: Functional principle of data sovereignty through mechanisms

4.3.2 The Mobility Data Space as a distributed system

Beyond the minimum example, a data space can consist of dozens or even hundreds of participants. This kind of decentralized, distributed system requires a central directory in which data sources and services are published and which can be searched either manually or automatically by data users. Therefore, existing regional and national mobility data platforms play a special part within the Mobility Data Space. With different operator and business models, one or more central components for the data space can be offered:

- A **data marketplace** (technically, a metadata directory), for the publication and displaying of data sources and their terms of use. Metadata needs to be provided in a machine-readable format so that devices such as automated vehicles, smartphones and IoT devices will be able to find and use them autonomously.
- A **vocabulary provider** that provides the necessary domain knowledge about traffic and mobility data formats (e. g., DATEX II, NeTEx) as well as APIs (e. g., SIRI, TRIAS) in the form of vocabularies and ontologies, thus ensuring the machine-readability and interoperability of data.
- An **identity provider** as a single point of contact that evaluates the trustworthiness of data providers, data users as well as data and data apps, and that also allows secure communication based on the aforementioned evaluations.
- A **data app store** for the easy registering and marketing of data apps (for the processing of data relating to mobility).

- A **clearing house**, the system‘s central logging component, that records transactions made within the distributed system in order to make them available to the relevant parties for purposes of billing and quality analysis at a later point in time.

The connector also allows the exchange of data between data providers and users via the platform. This facilitates the brokering of data through which data users can subscribe to data publications and receive the data provided by the respective data providers in real time. In addition to this brokering task, the connector can execute data apps, for example, to compile the data provided to the platform into new virtual data sources. This way, existing data platforms can be extended to receive sensitive data worth protecting as well as mobility data from data providers and other data platforms, and to transfer them in compliance with the usage policy to data apps for enhancement and exploitation.

4.3.3 Design and operation of central components

Due to the important role of the central components in the Mobility Data Space, additional organizational issues must be considered:

- The neutrality of the central components’ operator is an important prerequisite for a guaranteed discrimination-free exchange of mobility data. This neutrality may be ensured, for example, by a public authority or an association.
- The funding of the central components’ operation must be stable – not least for creating trust in the concepts of the Mobility Data Space. If operators have to raise user fees in order to cover their costs, the attractiveness of participating in the Mobility Data Space will decrease for all parties. In addition, funding models such as the promotion of data services might impair neutrality.
- There has to be a continuous harmonization of the data formats and models provided by the vocabulary provider. Communication and coordination with the relevant stakeholders is important to identify changing requirements of the data formats and models and to find solutions. Predefined processes can be a way to better include the stakeholders.
- Because license and usage policies are new for many parties acting in the field of mobility, examples and patterns should be offered.
- Although marketing does not play a key role in data exchange itself, it is an important element in broadening the implementation and knowledge about the Mobility Data Space. Because utilization of the central components lies in the interest of the central components’ operators, appropriate marketing is necessary.

Secure data space

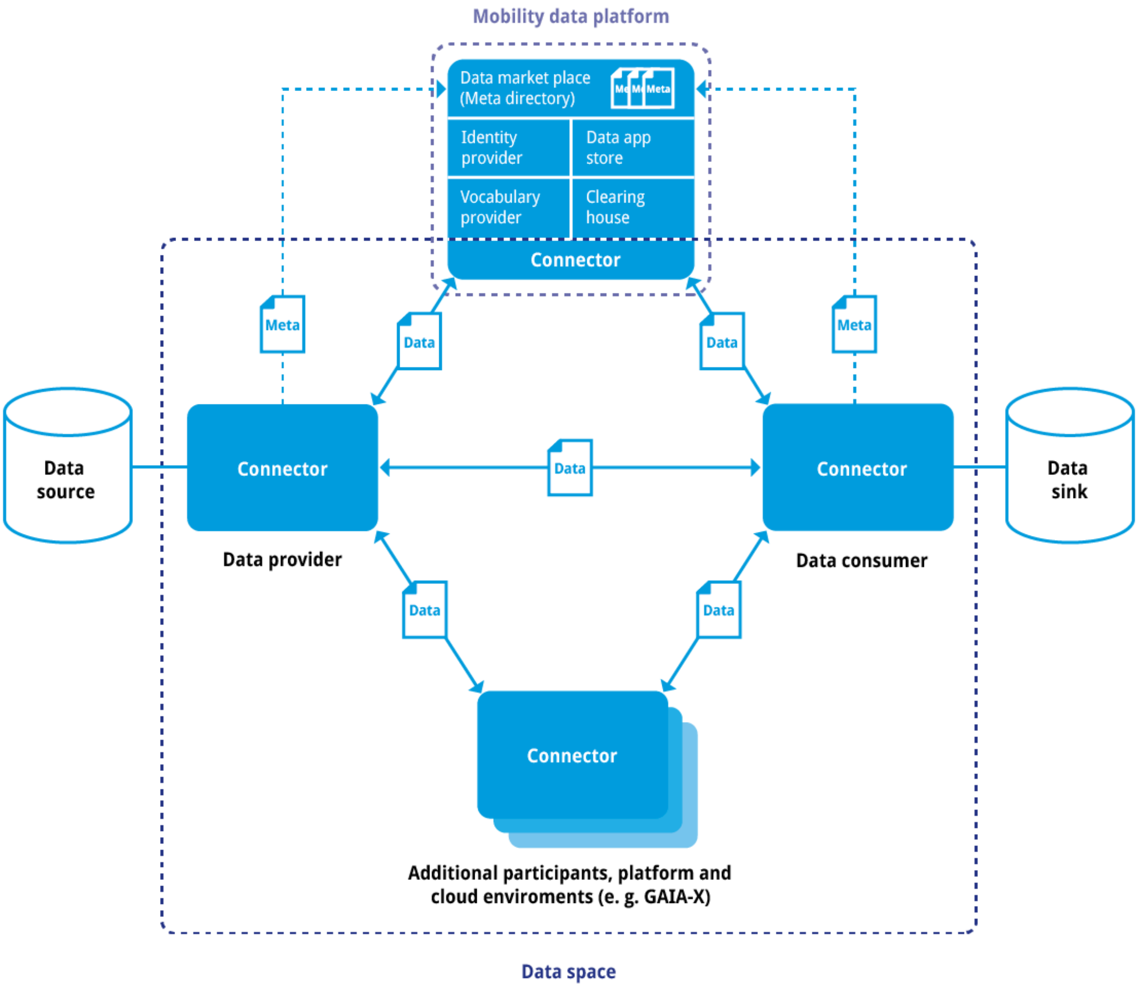

Figure 2: secure data space

4.4 The Mobility Data Marketplace (MDM) as central platform within the Mobility Data Space

The Mobility Data Marketplace (MDM) is a platform that already covers some of the concepts of the Mobility Data Space. The Mobility Data Space concepts can enhance the MDM's functionalities, thus increasing its attractiveness. The MDM is known as the central point of contact for road traffic data in Germany. Because it is operated by the Federal

Highway Research Institute (BASt), it has a neutral position. This way, data providers can rely on a neutral IT infrastructure that is not influenced by the interests of private economy. Currently, the most important providers of road traffic data are authorities on all levels of public administration, ranging from ministries to small municipalities. With the help of this data and the results of their processing by service providers, traffic participants will receive better information and both the safety and efficiency on roads will increase.

The MDM offers two core functionalities:

- The MDM has a metadata directory for searching relevant data publications. The directory's entries can be filtered according to various criteria.
- Due to its brokering functionality, the MDM is a data distributor: Through 1:n distribution, data provision is made easier for both data providers and data users. Data providers offer their data publications and interested data users can then subscribe to them. This means that the MDM is not focused on end users (travelers, users of a mobility app, etc.), but on establishing data exchange in the B2B sector (e. g., infrastructure operators and service providers).

For data exchange via the data distributor, the MDM primarily uses the DATEX II data model. This European standard is commonly used in traffic control centers and is required by law as a basis for the exchange of traffic data. The MDM website provides DATEX II profiles for several data types. With the help of these profiles, data providers can identify the requirements for the individual elements of their data publications, and data users know what to expect from the publications so that they are able to integrate them into their systems.

Some of the MDM's functionalities correspond with the core components of the Mobility Data Space:

- The data marketplace is the core functionality of the MDM. Metadata is searchable via a web-based user interface, but it is not machine-searchable. Also, it is possible to distribute usage and content data in addition to metadata via the data distributor. Through this type of 1:n distribution system, a large number of subscribers to a certain offer can receive real-time data while the data provider only has to manage one interface. This way, only the most recent data content is available in the MDM, and the historicization of data does not take place.
- The vocabulary provider functionality is already partly supported by the MDM through the provision of DATEX II profiles.
- While access to the metadata search is free, data providers and data users have to register as users for the MDM. The range of certificates is comparable to that of the identity provider functionality.
- In analogy to the clearing house, transactions are also logged in the MDM. However, a standardized procedure following the IDS concept is not implemented in the MDM.

The MDM is currently not implemented in an IDS-compliant way. The metadata directory is not machine readable, data distribution is not carried out via a connector, and the mobility vocabulary provider, identity provider and clearing house components were not created according to the concepts of the Mobility Data Space. Also, a data app store is missing.

Figure 3 shows how the MDM, as complemented by an IDS connector, could become a part of the Mobility Data Space, run data apps and broaden its spectrum of services through data processed by those apps. Looking at the necessary organizational aspects of a central platform within the Mobility Data Space, the MDM already considers various aspects relating to the operation of central components in a similar way:

- As a neutral operator, the MDM is trustworthy. Therefore, additional key roles, such as the identity provider, the app store provider and the vocabulary provider, can also be taken on by the MDM.
- Commercial services and advertising are currently not pursued in the MDM as ways to raise funds, as such practices might impair neutrality. However, should the hosting of data apps that explicitly create added value require extensive resources, fees might be considered.
- The limitation to DATEX II as the only model on the platform could be lifted. In particular, the increased inclusion of mobility data beyond road traffic calls for the adoption of additional data standards. In the future ecosystem, additional standards will be recommended and developed, and conversions between them will be supported. Therefore, it is imperative to harmonize the use of data standards.
- Machine-processible standard licenses offered by the MDM for some frequently occurring cases are conceivable.
- Marketing activities conducted by the MDM are realistic in the future. The MDM does not only wish to be a part of the mobility data ecosystem, but it also wishes to contribute to the onboarding of additional stakeholders. For maximum efficiency in terms of marketing, several important partners within the mobility data ecosystem should undertake joint steps.

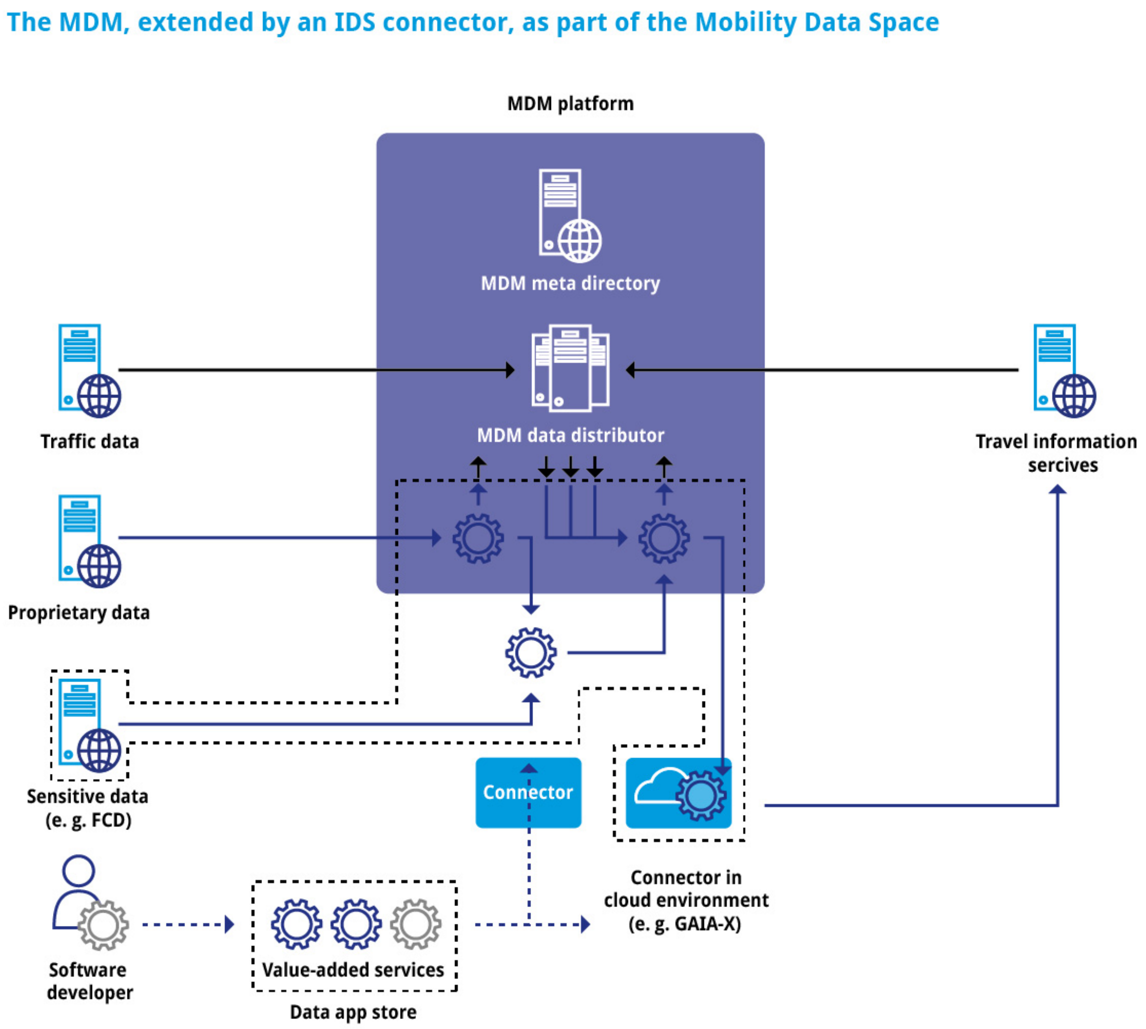

Figure 3: The MDM, extended by an IDS connector, as part of the Mobility Data Space.

4.5 Datenraum Mobilität (DRM) – A national implementation in Germany

In 2020, the German Federal Government has decided to implement and to promote the operation of a federated national Mobility Data Space „Datenraum Mobilität" (DRM), following the decentral architecture principles of the here presented Mobility Data Space concepts. A large-scale stakeholder and governance process, led by acatech (German Academy of Science and Engineering), has resulted in an extensive stakeholder engagement, supporting DRM by the provision of mobility data and the implementation of

DRM based use cases.

DRM will address the private and public sector equally in order to establish and promote a comprehensive mobility data ecosystem. A very important role will be played by existing data platforms (such as MDM, HERE), since they provide access to already connected participants and their data offers:

On behalf of the Federal Ministry of Transport and Digital Infrastructure (BMVI), acatech founded the non-profit organisation „DRM Datenraum Mobilität GmbH" in May 2021, together with further supporting public and private shareholders. This entity will bring the DRM in operation and will be responsible for legal and governance aspects.

On a technical level, the DRM will provide the central services that are necessary for the operation of a data space according to IDSA: a data marketplace (technically, a metadata directory), a vocabulary provider, an identity provider, a data app store and a clearing house (see also chapter 4.3.2). The data exchange is established directly between the participants themselves in a distributed manner by using IDSA-compliant connectors. The DRM operator has no touching point with the exchanged data itself as proposed in chapter 4.3, resulting in an opposite architecture then a data platform/data lake.

The DRM services are based on reference implementations by Fraunhofer, following the IDSA specifications. The interim operation of DRM is provided by Fraunhofer IVI, until a professional operator takes over in 2022.

4.6 Connecting data platforms

The connection of several platforms will result in comprehensive visibility and availability of data sources for data users. Mobility data in particular are generated and used on a regional level, either by communities or by fleet operators in private economy.

Currently, mobility data platforms are created on a regional level, e. g., by smart city initiatives, in order to pool the local services. Through the integration of these platforms and the data space concept, as well as through the resulting network, the MDM helps to make regional mobility data visible on a national level.

Further national data platforms with different focus topics, such as open data in mCLOUD, and commercial data services, such as geodata, vehicle data or navigation services, can also be combined into an ecosystem with the help of data space concepts.

Cloud services provide a further level of networking. With the help of their resources, cloud services create scalability for business models in the field of data exploitation and management. It is thus possible to offer customized CPU-intensive prediction models, AI applications and high-volume data analyses, which would be impossible for just one conventional platform.

The use of resources and the resulting costs for cloud computing can be tied to customer demand, which means that they can be planned and calculated. Hosting an IDS connector in a cloud environment is just as secure as hosting it on a platform, the only difference being that a cloud-hosted connector is scalable according to the demand.

In addition to that, cloud environments, just as single platforms, are also often data and service ecosystems. Thus, the data offered by a connector is made available for additional interested parties within the cloud ecosystem.

The GAIA-X initiative, which is currently being promoted by the German federal government, gives an outlook on the prospective network of cloud ecosystems. The technological core of the initiative aims at connecting several European cloud environments with the help of data space concepts to form a connected infrastructure.

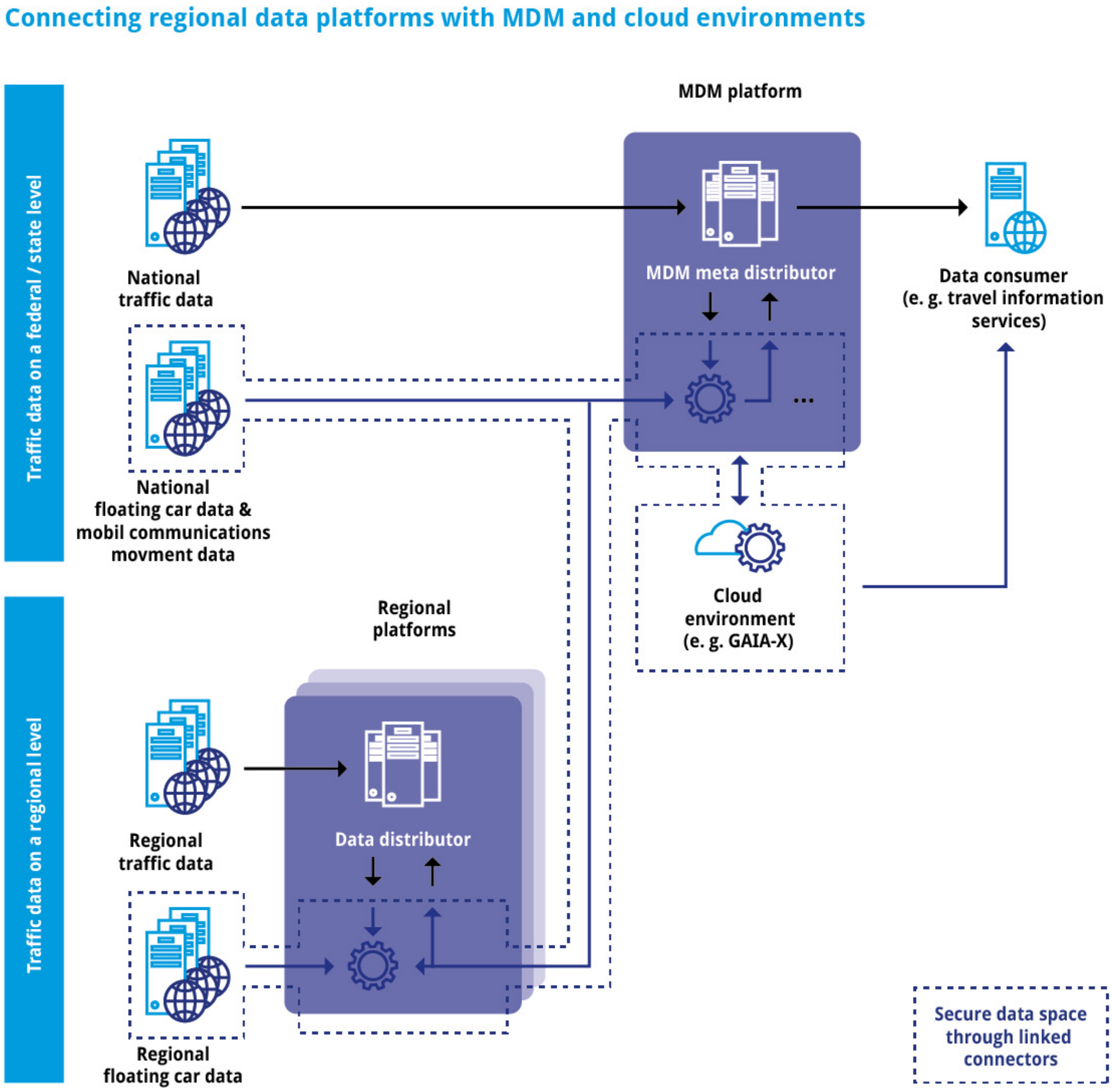

Figure 4: Connecting regional data platforms with MDM and cloud environments

4.7 Application example: mobility service provider

The following example illustrates the potential of a mobility data ecosystem as pictured above including the MDM and additional decentralized stakeholders: A mobility service

provider wants to offer short trips on dynamic routes. Their business model only works if they can serve a large number of customers per trip and direction.

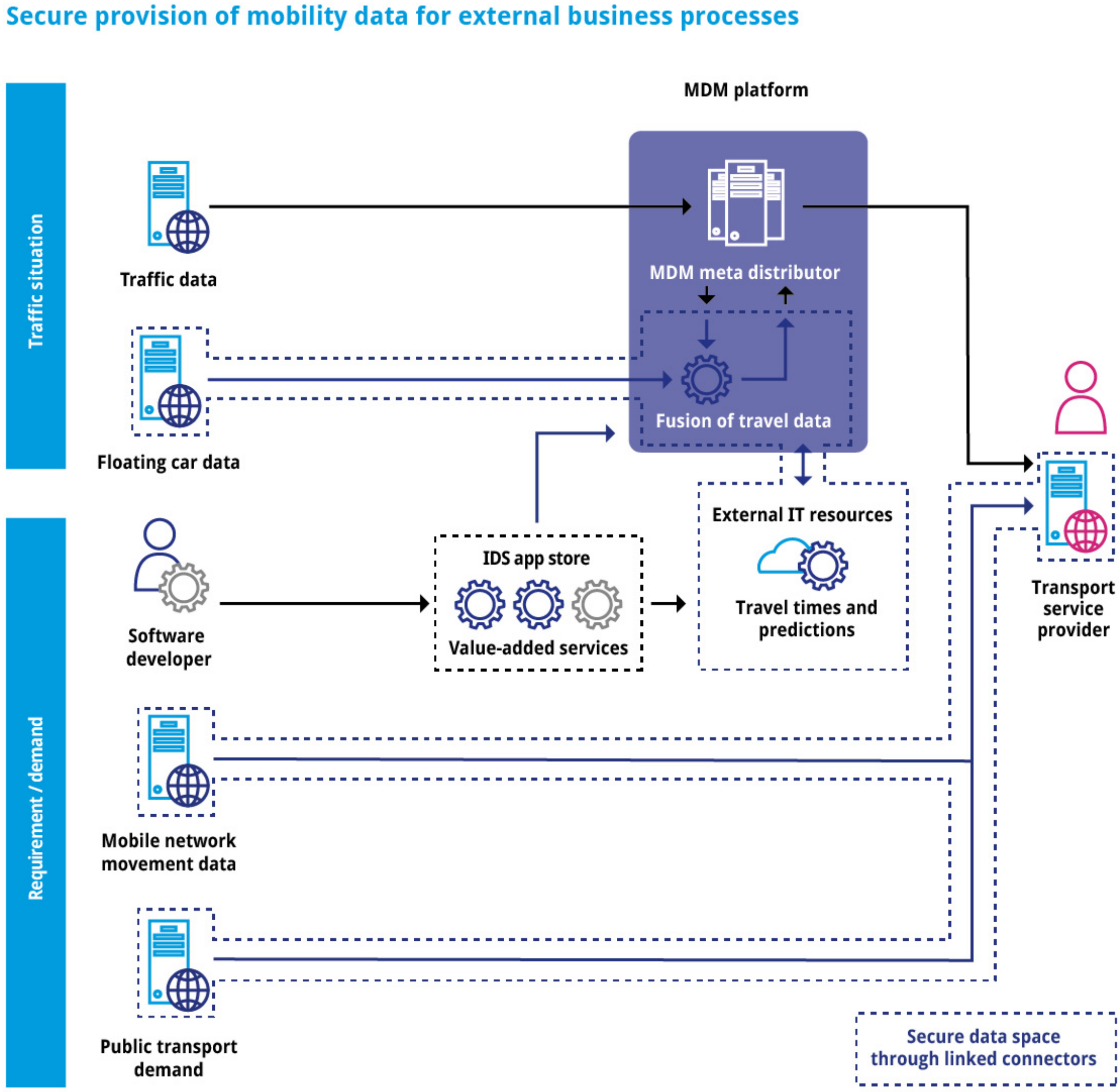

Figure 5: Secure provision of mobility data for external business processes

For routing and achieving optimal travel times, they need traffic state information. This information is gathered by road operators, road administration offices and environmental agencies through traffic monitoring, and provided via the MDM. This is already a daily practice.

In order to achieve the highest possible occupancy rate of their vehicles, the service providers also need mobility data, movement data and demand data.

Fleet operators (taxis, logistics, public transport) as well as providers of navigation services are already gathering floating car data (FCD) representing individual traveling speeds. This type of data is highly sensitive because it contains personal driving profiles. For this reason, the transfer of raw floating car data to third parties has been impossible so far.

In the depicted scenario, both the data provider and the MDM have an IDS interface (IDS connector). In this data space, the data provider can control how their sensitive floating car data may be processed by the MDM and in what shape they may be transferred from the data space to the data user after processing.

In doing so, data providers can offer their sensitive data for external business processes without the fear of unauthorized data exploitation for other purposes than originally intended.

It is also possible to transfer data directly to users without a central platform, such as the sensitive movement profiles gathered by telecommunications and transportation providers referred to in this example. In this case, the data is processed within the data users IDS connector for utilization in their business processes and in compliance with the data providers‘ specifications.

Data processing (traffic data fusion) is realized by a data app whose compliance with the data providers‘ requirements has been verified by a certification agency. The app is run within the MDM‘s IDS connector. This app and other data apps may be developed by an independent software developer and offered in an app store. App development may be commissioned by data providers/data users, but it is also possible for stakeholders to develop apps on their own initiative with the aim of implementing a business model.

Data that has been enriched by an app is a potential new data source available to MDM users.

This way, data apps can become the basis for a novel mobility data ecosystem. The IDS‘s decentralized architecture allows the integration of further IT resources. In the above example (see Figure 6), the architecture is extended by an external cloud environment that runs a more complex data app for the calculation of travel times and predictions.

4.8 A common mobility data space: on a European level

The European Commission has requested the establishment of Real-Time Traffic Information

National Access Points (NAPs) that are a prerequisite for the uniform handling of mobility data across Europe. The legal basis for this can be found in the ITS Directive no. 2010/40/EU. According to the directive, all member states are obligated to offer a platform on which at least the respective states‘ mobility data metadata description can be published. In addition to the ITS directive, several delegated regulations specify the data providers' obligations to publish mobility data via the NAP:

Safety-Relevant Traffic Information

According to the delegated regulation no. 2013/886, end users are to be granted free access to general safety-relevant traffic information (SRTI). This means that road operators in particular are obligated to provide existing data, e. g., on road works or exceptional weather conditions. This data is often used by service providers and forwarded to their clients.

Through increasingly connected vehicles, more and more private parties are in possession of safety-relevant information that can help, for example, to detect temporarily slippery roads. Because this data has the potential for commercial exploitation, there are reservations concerning its disclosure. The sharing of data in a secure data space can be a way to reduce these reservations.

Real-Time Traffic Information

The same applies to the provision of real-time traffic information (RTTI) across Europe in compliance with the delegated regulation no. 2015/962.

This regulation calls for the publishing of data on traffic volume and traffic jams, as well as dynamic speed limits and road closures via the NAP. In addition to road operators, this

regulation also increasingly affects private parties with access to vehicle data.

Multimodal Travel Information Services

The delegated regulation no. 2017/1926 on the provision of multimodal travel information services (MMTIS) across the EU demands that both static and dynamic, as well as historical travel and traffic data are to be published via the NAP by traffic authorities, transport providers, infrastructure operators and providers of demand-based transportation services.

This multimodal travel planning and information services need to be linkable. This way, Europe-wide services can be created for end users.

Although the aforementioned legislative initiatives obligate private companies to provide data in high volumes, enterprises often fear the disclosure of business secrets and customer data. The sharing of sensitive data in a secure data space such as the Mobility Data Space will help alleviate these fears. Data providers can trust that their data will only be exploited according to the terms and conditions of use and licensing specified by them, and that they will be able to control and monitor the usage.

Another obstacle for the utilization of European NAPs for internationally acting enterprises, such as vehicle manufacturers and navigation service providers, is the fact that there still is a large number of platforms in Europe. Ca. 30 NAPs, some of which differ significantly in the way they are implemented, need to be supplied in order to offer services internationally. The further harmonization – or, even better, the connection of European NAPs through the concepts of the Mobility Data Space – would certainly be widely welcomed.

This can be the first step towards a common European mobility data space as envisioned within the Commission's COM 2020/66 data strategy. On the whole, the Mobility Data Space includes all concepts necessary to »facilitate access, pooling and sharing of data from existing and future transport and mobility databases«.

A European data strategy

On February 19, 2020, the European Commission published the Communication 2020/66, introducing a European data strategy. This strategy explicitly promotes the creation of Europe-wide data spaces in different sectors including the mobility sector:

» [...] a Common European mobility data space, to position Europe at the forefront of the development of an intelligent transport system, including connected cars as well as other modes of transport. Such data space will facilitate access, pooling and sharing of data from existing and future transport and mobility databases. [...] «.

Currently, it seems likely that this document will influence European legislation regarding the provision of data at National Access Points as well as different funding instruments.

4.9 Implementation within mFUND research projects

The foundations for the development of the Mobility Data Space were laid in two mFUND projects funded by the Federal Ministry of Transport and Digital Infrastructure (BMVI): »Vorstudie-MDM-MDS « (12/2017 to 05/2018) and »Mobility Data Space« (06/2019 to 05/2022).

Within the »Preliminary Study on Connecting the MDM to the Intended Mobility Data Space« (Vorstudie-MDM-MDS) project, BASt, Fraunhofer IVI and Fraunhofer IAIS developed potential improvements to the MDM through an integration concept for MDM and IDS components. The concept investigates different multimodal and intermodal mobility scenarios, considers the integration of open data from the mCLOUD and illustrates potential contributions from the MDM/ MDS that can help establish the future National Access Point for multimodal travel information.

This preliminary study is the basis for the implementation of the intended Mobility Space within the scope of a follow-up research and development project. It answers organizational, functional and technical questions regarding the development, operation and use of the Mobility Data Space.

In order to motivate relevant stakeholders to participate in the Mobility Data Space, the study's scientific results were presented at several relevant expert conferences such as the 2018 ITS World Congress, the MDM Conference and the mFUND Conference, as well as a number of industry symposia.

The preliminary study resulted in a technical and temporal roadmap for the Mobility Data Space that will be updated and implemented within the mFUND »Mobility Data Space« project.

The project »Mobility Data Space: Connecting local, regional and national data platforms through data space concepts, as well as enrichment and exploitation as a mobility data ecosystem« aims to initiate the development of the Mobility Data Space, which will establish itself as a mobility data ecosystem by including the Mobility Data Marketplace by BASt as well as additional regional traffic data platforms.

New local traffic data and nation-wide mobility data will be acquired and provided for secure and sovereign processing on platforms extended by data space concepts. By connecting regional platforms with the MDM, it will be possible to provide and exploit regional data on a national level.

Within the project, the MDM and further local platforms will be improved for the support of data-driven services. To achieve this, they will be expanded by a secure and protected execution environment for services and data apps in which mobility data can be provided and processed under guarantee of data sovereignty. This way, sensitive mobility data such as floating car data (FCD) will be exploitable for the first time.

By connecting the MDM with local platforms into a decentralized data space, a federal mobility data ecosystem will be created. With this ecosystem as a basis, complex real time use cases can help lower environmental impact, optimize traffic flows and improve multi-modal commuter information services.

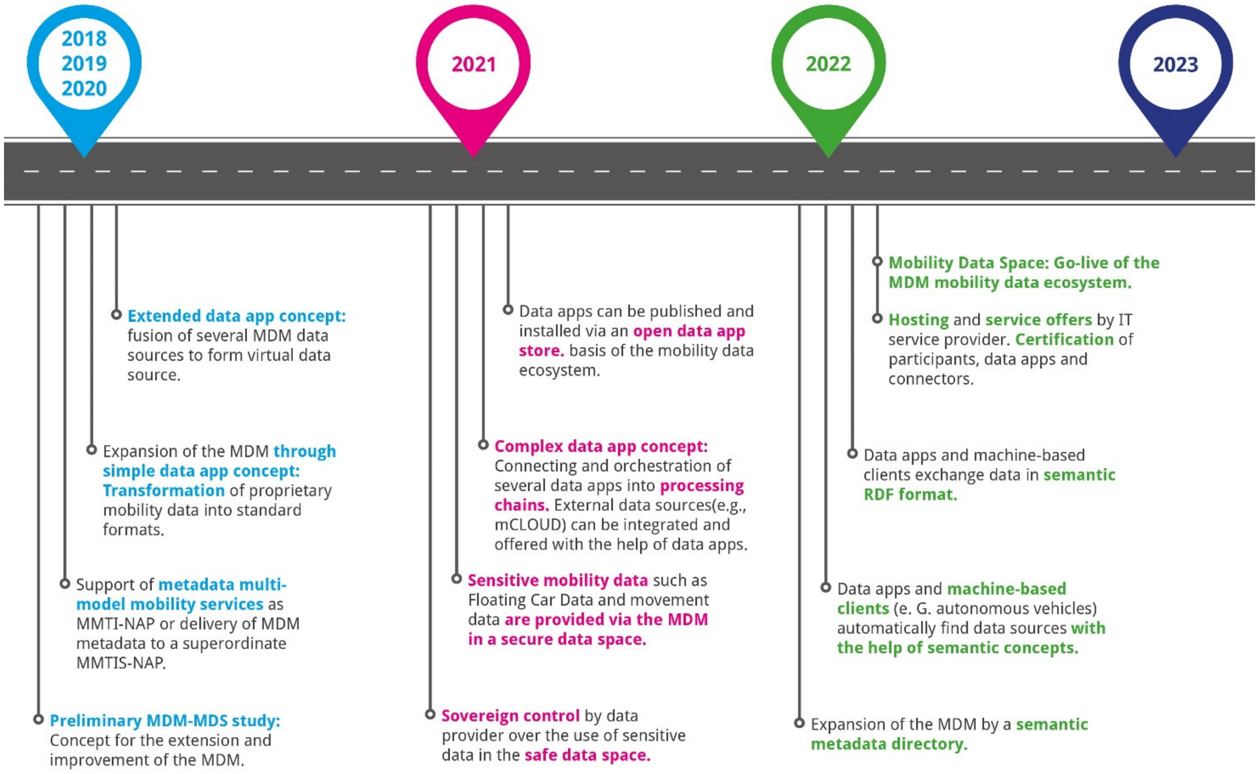

Figure 6: Development roadmap for the Mobility Data Space.

References

Acatech (2021) „Vernetzter Verkehr: acatech initiiert Trägergesellschaft „DRM Datenraum Mobilität GmbH" als Non-Profit-Organisation – acatech" [online] URL: https://www.acatech.de/allgemein/vernetzter-verkehr-acatech-gruendet-traegergesellschaft-drm-datenraum-mobilitaet-gmbh-als-non-profit-organisation/

Bundesministerium für Verkehr und digitale Infrastruktur (2017). „BMVI - Vorstudie Verknüpfung des MDM mit dem geplanten Mobility Data Space – Vorstudie-MDM-MDS" [online] Bmvi.de. [online] URL: https://www.bmvi.de/SharedDocs/DE/Artikel/DG/mfund-projekte/vorstudie-verknuepfung-des-mdm-mit-mds-mdmd-mds.html [retrieved August 5, 2021].

Bundesministerium für Verkehr und digitale Infrastruktur (2019) „Verknüpfung kommunaler, regionaler und nationaler Datenplattformen durch Data-Spaces-Konzepte sowie Veredelung und Verwertung als Mobilitätsdaten-Ökosystem-Mobility Data Space" [online] URL: https://www.bmvi.de/SharedDocs/DE/Artikel/DG/mfund-projekte/mobility-dataspace.html [retrieved August 5, 2021]

Drees, Holger & Kubitza, Dennis & Theissen-Lipp, Johannes & Pretzsch, Sebastian & Langdon, Christoph. (2021). Mobility Data Space - First Implementation and Business Opportunities

EC European Commission (2020) „A European strategy for data", Brussels, 19 February 2020, URL: https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:52020DC0066 [retrieved August 5, 2021]

Fraunhofer ISST (2021) „International Data Spaces" [online] URL: https://www.fraunhofer.de/en/research/lighthouse-projects-fraunhofer-initiatives/international-data-spaces.html [retrieved August 7, 2021]

International Data Spaces Association (2021) "The Association – IDSA: Driving data freedom for the whole world" [online] URL: https://internationaldataspaces.org/we/the-association/ [retrieved August 5, 2021]

CONTACT

Head Office

INTERNATIONAL DATA SPACES ASSOCIATION

Emil-Figge-Str. 80
44227 Dortmund | Germany

phone: +49 231 70096 501
mail: info@internationaldataspaces.org

WWW.INTERNATIONALDATASPACES.ORG

@ids_association

international-data-spaces-association