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Mobility Data for a Just Transition:

The Case for Multimodal Platforms and Data-Driven Transportation Planning

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Content

Executive Summary

The current, private car-based mobility system is not sustainable: it contributes to climate change, it is unjust from gender- and socio-economic perspectives, endangers health and obstructs urban space. To counteract this, mobility data offers entirely new avenues for planning, organizing, and implementing mobility and transport. This strategy paper considers two possible ways to use mobility data for improving environmental sustainability and equitable access to transportation in Germany:

1. **Availability of data for better mobility management and transportation planning**

   Movement data generated by mobility services and GPS-enabled cell phones provides a new foundation for planning mobility compared to the previous methods of traffic counts and household surveys. Populations' mobility and traffic flows can now be tracked and analyzed across all modes of transport, including starting points and destinations, in real time. Based on this data, transportation planners and mobility managers are able to develop infrastructures and mobility services that respond better to demand. Yet staff and budget shortages prevent urban mobility managers from utilizing mobility data - even when it is available. This report offers recommendations for easier access and higher usability of data for mobility management.

2. **Mobility-as-a-Service (MaaS)-platforms**

   Mobile internet access enables flexible, responsive mobility services, which include car, bike, and scooter sharing, ride-pooling, and other forms of shared mobility. MaaS-platforms connect these services and allow easyaccess to information and booking options so that users don't have to navigate a multitude of apps and accounts. They enable transfers between mobility services and other sustainable transport modes - public transit, cycling, and walking - enabling convenient, sustainable mobility without private cars. This is why, when set up with sustainability goals in mind, such platforms could be a powerful lever to help bring about a just mobility transition.

   But currently, public resources are wasted on a multitude of platforms, which use incompatible data standards and integrate only a fraction of the available services.

   While most commercially operated MaaS platforms can be used nationwide or beyond, they prioritize on the fleets of commercial mobility service providers, which focus on profitable inner-city areas, and hence do little to address social and environmental problems while creating the risk of mono-/oligopolies. Public mobility platforms, on the other hand, integrate public transit services and connect sharing services with the aim to provide general public utility and to reduce car traffic. Yet currently, they often only integrate a fraction of the available services.

Key recommendation

Following a pioneering phase that brought about a multitude of platforms with different levels of integration, models of cooperation, and interfaces, there is now an opportunity to pool scarce resources and exploit synergies. This report provides the following recommendations to achieve these goals in Germany:

Mandate data sharing and payment interface for private mobility service providers: Based on the EU Directive on Intelligent Transport Systems, and emulating legislation in Finland, all mobility service providers in Germany should be obligated to make static as well as dynamic information on their services available to other mobility service providers, public institutions, and for research purposes via the National Access Point. In addition, a mandatory payment interface would allow third parties to book and bill all mobility services available in Germany.

Following such a regulation, all (public and private) mobility providers could offer integrated platforms that cover all available mobility services in Germany. This would not only reduce personnel and financial expenditures in the public sector, but also enable citizens to seamlessly travel beyond the boundaries of their municipalities and public transit systems without a private car. This approach also boosts innovation, as customers could find smaller providers more easily and all mobility service providers could develop their services with a better understanding of actual demand. In addition, the market power of platform companies would be reined in, especially if accessing mobility data via the National Access Point came with an obligation to display all available options of a given mobility mode without discrimination.

A mandatory nationwide data-sharing obligation would also support transportation planning and mobility management. Data on all local mobility service providers would be available in a uniform format, and suitable tools for evaluation could be provided consistently nationwide. It would empower municipal staff, policy makers, transportation planners, and researchers to gain a comprehensive overview over how mobility services are used locally and beyond. It would also unlock digital capabilities for small municipalities with lower levels of data literacy and weaker leverage vis-à-vis mobility service providers.

The above approaches could improve the quality and user-friendliness of mobility services in both urban and rural areas, making sustainable mobility more attractive. Used correctly, mobility data can make an important contribution to a just transition in the transportation sector.

1 Introduction: Mobility Data to serve the Common Good

The world of *mobility*[1] is in a process of transformation. The car-centered mobility systems of industrialized countries are being challenged because they exacerbate climate change, threatening the very foundations of our existence. At the same time, a rising number of vehicles is taking up more and more space. In cities and communities around the world, citizens are demanding safe and livable public spaces – "quality of life for all."

The precedence of automobile traffic must be curtailed in order to break its dominance. Alternative mobility options must become far more attractive. Digitization has enabled a range of new *mobility services*: Bike, *scooter, and carsharing* or *on-demand ridepooling can be found and booked via smartphone apps*. They complement what is called the "ecological network" of public transport, cycling, and walking, and they are becoming available in more and more places. Oftentimes, only the combination of different *mobility modes* truly constitutes an attractive alternative to private car ownership – for example, a bike rental to cover that last mile from the suburban train station to your final destination. If we can better connect different mobility modes, car-free travel not only becomes possible in the first place, but travel options also become denser and more frequent. Different means of transport should be interconnected both physically and digitally: Mobile stations, for example, offer different means of transport at the same location. Over a joint app, these services – public transport, but also shared vehicles or bike boxes – are easily located and booked.

The increasing availability of real-time location data for both users and vehicles is a quantum leap in spatial and temporal accuracy and for analyzing mobility patterns. This way, mobility management can better align mobility systems with user needs as well as with other objectives, such as social inclusion and climate protection, for example by optimizing public transport or by setting traffic lights to "green waves" for cyclists. Whether this "update" for the transportation system will succeed depends mainly on the strategies, competencies, and resources of municipal mobility management.

In the authors' view, the digital integration of various mobility services and improved data availability for municipal mobility management are key for socially and environmentally compatible mobility.

1 This and other terms are defined in the glossary.

1.1 MaaS platforms: Risk of monopolization and opportunities to centralize services

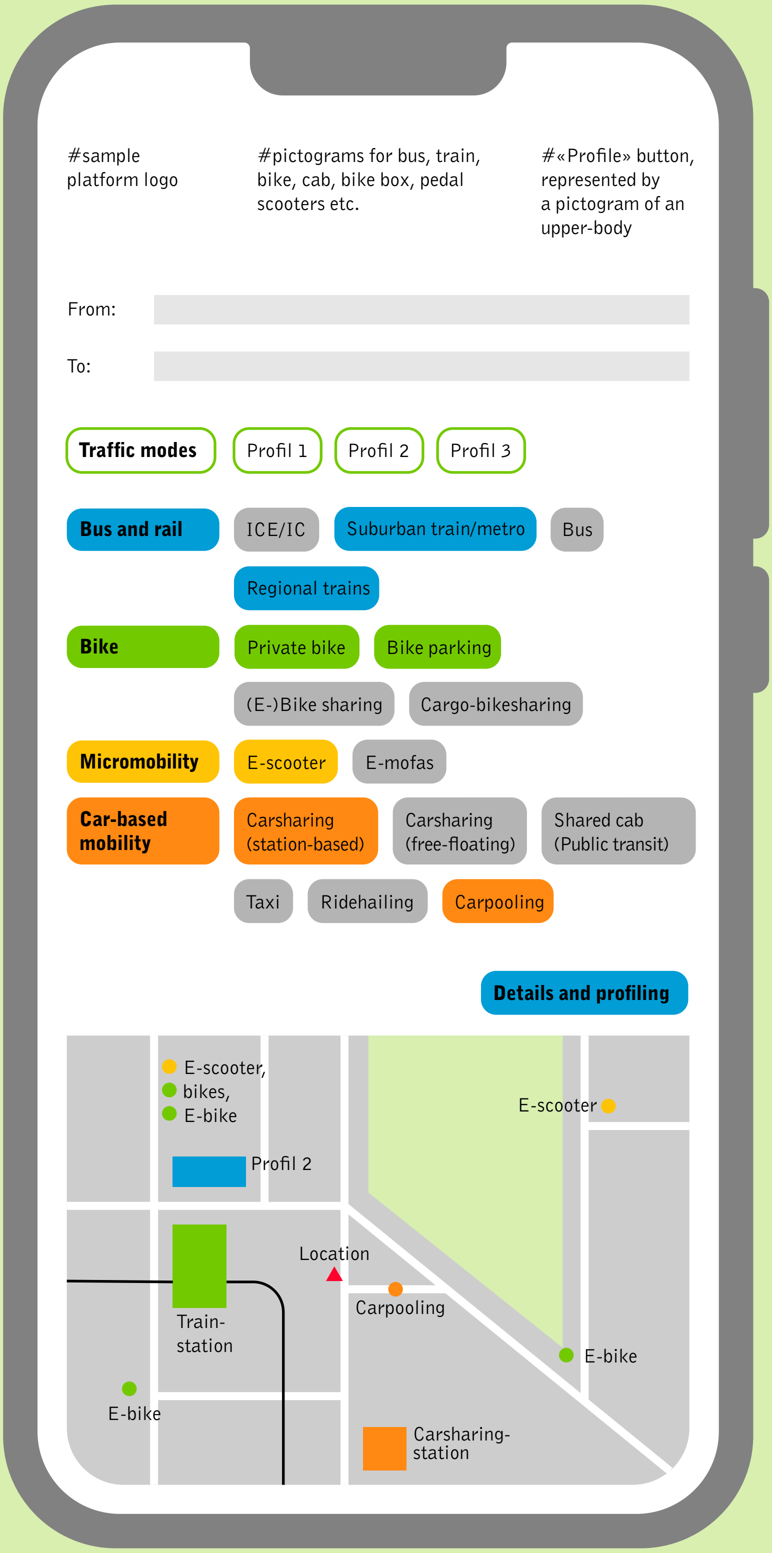
In recent years, the range of available mobility services in Germany has grown steeply. *Station-based* as well as free-floating car, bike, and e-scooter sharing services have emerged in many cities, along with individual and pooled on-demand ride services. At the same time, some newly developed mobility platforms now display several such services in one app, based partly on what is called *deep integration*, enabling direct booking without having to switch to the provider's app (see box 1). Some platforms have evolved from private ventures (e.g. ShareNow), while others were launched by *public transport companies*/associations or municipalities (e.g. Jelbi in Berlin, hvv switch in Hamburg).

Mobility-as-a-Service platforms (MaaS) follow the same logic as any other sector of the platform economy: The more services are available on one platform, the more attractive it is for users. And the more users, the more cost-efficient the platforms are for providers. This can lead to monopolization – posing similar problems for consumers and competitors as we have seen with platforms such as Amazon or Google. Dominant private platforms could, for example, display only those offers that earn them the greatest profit, which would undermine the environmental and social potentials of mobility services (cf. Piétron et al. 2021).

So far, however, the German MaaS business has been driven mainly by publicly financed transport companies and associations. Many public actors at various levels are currently embarking on this journey at widely varying speeds. Historically, German public transit has evolved as a mesh of responsibilities between municipalities, states, transport and special-purpose associations, organized according to the principle of subidiarity. This affords local players a great deal of freedom to set their own prices and adapt to local conditions, but it also has some disadvantages. In many places, new MaaS platforms or mobility *dashboards* are funded by municipalities and grant programs. The search for solutions to problems that have already been solved is a waste of time and resources for local authorities and transport companies. It also generates applications with poor usability and causes a proliferation of digital interfaces (application programming interfaces, APIs). Linking these localized solutions to other systems costs municipalities and transport companies even more money, e.g. in terms of personnel. Since the challenges, and thus the required software, are often similar, using existing solutions or jointly developing solutions at the state and federal level could create great synergies. Currently, the hardware and software equipment of transport companies is highly disparate. For instance, North Rhine-Westphalia offers a uniform, GPS-based check-in/check-out system for all its buses and trains, while some other transport companies are struggling to even implement the digital Germany-wide "Deutschlandticket".

In the age of digitization, this patchwork of digital infrastructures is inadequate. Greater standardization and joint development could become a catalyst for transregional, user-friendly public sector platforms. Such a paradigm shift would not only benefit citizens and the climate, but could also help relieve the burden on local governments, transport companies, and associations, many of whom are so strapped for cash and personnel that they are unable to deliver on their visions.

Box 1: Our vision: An app to search and book e-scooters, buses, bike boxes, and any other mobility services across Europe.



All mobility options at a glance, filtered according to the user's preferences. An alternative to private cars could be as simple as this. Whether it is a bike rental or a bus or cab ride – it can all be booked on the user's mobile device. MaaS apps like Jelbi in Berlin show that booking a variety of different mobility services on a single app is technologically feasible today (deep integration).

Fig. 1: Sample interface of a *non-discriminatory* **MaaS app**

1.2 Data-driven mobility management as a building block of a just transition in the mobility sector

Municipal mobility management used to rely on sporadic traffic counts and large-scale household surveys to analyze mobility behavior. They would then use this information as a basis to plan infrastructures and control traffic flows. However, these instruments fall short when it comes to analyzing localized traffic patterns in a wider context, for example, to identify optimal locations for mobile stations, connect bicycle expressways, or organize public transport services. In recent years, general mobility data has been getting more comprehensive and detailed, especially thanks to smartphone use. In addition, digitally-based mobility services – such as bike sharing – are generating new data sets that are increasingly becoming available to municipalities. Both can help municipal mobility management to make better decisions at the strategic and operational levels. But how do cities get their hands on such data sets? And how can a small community use and evaluate them without specialized personnel?

In addition to the opportunities outlined above, the technological and social innovations that come with mobility data also entail general risks and disadvantages for individual actors and social groups:

Individuals, for example, may be putting their data protection and data sovereignty at risk. In addition, factors such as age, income, place of residence, tech skills, and social roles determine who profits most from these new services, and some will benefit more than others.

For both private and public mobility providers, disclosure of their vehicle and usage data might compromise sensitive business interests. Booking mobility services via intermediary platforms – instead of directly with the mobility provider – also raises questions around distribution sovereignty, customer access, and market power of the players involved. There are concerns that well-funded digital corporations will take the lead and relegate public transport companies to mere subcontractors.

Even in terms of sustainability, the bottom line might end up negative if the new services lead to higher traffic volumes.

Increasing reliance on digitally integrated systems for mobility also harbors another systemic risk: large-scale disruption to public life due to hacker attacks.

Network effects and economies of scale might create monopolies for successful players, stunting innovation and competition.

1.3 Focus and methodology

This policy paper explores ways to advance the adoption of comprehensive, intermodal booking platforms at the municipal and national levels, as well as ways for municipal administrations to use mobility data to better position and align public and private mobility services and leverage synergies. This study addresses the following questions: How can we advance intermodal MaaS platforms that contribute to sustainable mobility, social participation, and guarantee data protection? How can we better use mobility data to optimize municipal mobility planning? What would be the appropriate legislative framework and suitable organizational and cooperation models to achieve these goals?

To analyze these questions with a view towards practical implementation, we conducted 16 interviews with various stakeholders as well as an extensive literature review. Among the respondents were representatives of public institutions, such as municipalities, municipal transport companies, *transport associations*, and state-level as well as federal institutions. We also talked to providers of sharing services, MaaS platforms, data standardization organizations, and researchers engaged in data protection and bike traffic data.

2 Sustainability of MaaS Services

MaaS platforms can play an important role in the mobility transition, provided that several conditions for their sustainable implementation are met: Using the platforms should have ecological benefits, strengthen social inclusion, and be compatible with data protection compliance.

2.1 Ecological sustainability

The core function of MaaS platforms is to improve the accessibility of mobility services. Thus, they encourage vehicle use by multiple users, either at different times (such as car or bike sharing) or in parallel (e.g., on-demand ridepooling). This can reduce the number of vehicles and thus help make mobility more sustainable without even changing the mode of transport (Weber et al. 2020, p. 26). Shared vehicles do not require driving staff, making it possible to offer sustainable public transport options in areas and during time periods where traditional mass transit would be too expensive and have a poor environmental footprint. Mobility services promote car-free mobility by complementing the ecological network of public transport, walking, and cycling. They serve as "feeders" to public transport (Schimohr and Scheiner 2021), thus improving its accessibility. Additional environmental benefits accrue when less resource-intensive modes of transportation are used. However, when people end up switching to less eco-friendly transport services, the eco-balance can also be negative. In addition to emissions generated during use, we must also take into account the resources needed to produce the vehicle.

In addition to these immediate effects, there will be changes to the overall system. If more people use mobility services, these services grow and become more attractive. In addition, policy measures like fewer parking spaces or stricter speed limits become more viable because voters who are personally less dependent on a private car are more likely to support them (Ruhrort et al. 2020). Moreover, the new services encourage society and policymakers to reflect on mobility behavior and the mobility system.

In the following, we will present some findings on the environmental performance of different mobility services.

Micromobility

This category includes a variety of mobility modes, such as shared bikes, e-bikes, and e-scooters. Studies on the ecological impact of micromobility have come to different conclusions – often based on relatively short observation periods. Considering only their emissions during use, these vehicles have a very positive impact, since they are largely powered by muscle power or electricity. Considering their entire life cycle, including production and redistribution of vehicles within the service area, the bottom line looks much worse and can even be negative (Teixera et al. 2020, p. 332). Regarding the life cycle assessment of e-scooters, Gebhardt et al. (2021, p. 34) estimate their carbon footprint to range between 80-340 g CO_2/km, depending on the total mileage, the type of drive used in the service vehicle, and the level of emissions required for production.

The key question here is which means of transport they replace. This differs greatly depending on which mode dominates the local modal split (i.e. the choice of transport). For the U.S., a survey study states that 25 to 40 percent of e-scooter trips replace car trips (Wang et al. 2023, p. 18). For Germany, Weschke et al. (2022) found that about 11.5 percent of e-scooter trips substitute car trips, while 60 percent substitute walking trips, and 7 percent would not have occurred at all without e-scooters. In both countries, when car mobility is unattractive due to scarce parking and congestion, e-scooters tend to replace car mobility more often (Weschke et al. 2022).

Reck et al. (2022) compared the effects of privately owned versus shared e-scooters or e-bikes. They concluded that shared vehicles increase emissions while privately owned scooters and e-bikes lower emissions due to their longer lifespans and lower maintenance-related emissions. However, since the availability of shared vehicles is also a factor impacting the purchase decision for a private micro-vehicle, they may also reduce emissions in the long run.

Car-based mobility

The environmental performance of car-based mobility services varies when the different types are considered separately: Free-floating carsharing and ridehailing provide convenient access to car-based mobility. Depending on the context, they can increase the number of car trips (for ridehailing, see Siddiqui 2018) and shrink public transit revenues (Fitzsimmons 2018). Ridehailing, like on-demand ridepooling, typically involves empty trips since vehicles drive to pick-up and drop-off locations without passengers, which results in increased traffic. However, on-demand ridepooling might also reduce car trips because it pools multiple passengers.

Free-floating carsharing can be a transitional solution for people who intend to buy a car in the future, but whose current life situation prohibits private car ownership (e.g., income, parking availability) (Stallmann 2023, p. 128). That means these services can encourage adopting a car-centric lifestyle.

On the other hand, a solid body of research on carsharing in Germany shows a clear correlation between carsharing and a drop in private car ownership (Gisel and Nobis 2016, pp. 216-217). While free-floating carsharing is less likely to replace private cars than station-based carsharing, both types of systems are an important factor in a user's decision to get rid of their private car, or to not buy a new one. This effect is particularly pronounced when carsharing vehicles are readily available (Giesel and Nobis 2016, p. 223). Push measures, such as reducing parking spaces, further help eliminate cars in this context (Arbeláez Vélez and Plepys 2021, p. 13).

In his comparison of users of the two types of systems, Kopp (2015, p. 236) found that users of free-floating vehicles are more pragmatic about their carsharing habits, switching to other modes of transport with greater flexibility. Ruhrort et al. (2020) also found that free-floating vehicles hold great potential for eliminating privately owned cars: About 50 percent of the surveyed car owners said they could see themselves going car-free (n=800), and 24 percent of respondents who do not own a car said they would buy one if it weren't for carsharing. A study on the free-floating sharing system ShareNow (now FreeNow) found that substitution rates vary widely between cities. However, across the ten cities considered in Europe, one shared car replaces more than eleven private cars on average (Jochem et al. 2020). A recent UBA report concluded that carsharing can lead to a 10 percent reduction in all private vehicles, saving 3.9 to 6.7 tons of CO_2 per year. According to a study by the German Federal Environmental Agency, carsharing has by far the highest CO_2 savings potential of the 13 measures considered in different areas (including food, heating) (Fischer et al. 2022, pp. 12-14).

However, for an overall view of the impact of all mobility services – whether cars or micro-mobility – it is crucial to consider the role of these vehicles in the transportation system. If they are a complementary addition to the larger ecological network, they can help shift users from the car to public transport for longer trips. This effect may significantly outweigh the shift from walking to sharing or pooling mobility. In the overall picture, this may tip the scales in favor of mobility services.

Increased energy consumption due to IT

New mobility services and data-driven mobility planning require a variety of technological components, such as vehicle tracking, route calculation, and sharing data between mobility service providers. Currently, digital infrastructure accounts for approximately 1.8 to 3.3 percent of global greenhouse gas emissions. A large proportion is owed to the production of devices and the entertainment industry (Fokusgruppe Digitale Netze und Nachhaltigkeit 2020, p. 3). The more complex the mobility services and the required calculations, the higher the energy requirements for their production, maintenance, and operation. Any measurable reduction of motorized individual transport (MIT) and private cars likely outweighs these effects significantly. Nevertheless, systems should be designed to be energy efficient and to exploit the waste heat they generate (ibid., pp. 4-5).

Setting the right framework

It is difficult to estimate the overall ecological impact of new mobility services and their associated MaaS platforms. It greatly depends on the general conditions.

As congestion and scarce parking spaces make private cars less convenient, micromobility becomes the better option. Therefore, the introduction of multimodal platforms should be accompanied by a redistribution of public space at the expense of private motorized transport. Since long service life, low emissions during production, and climate-neutral maintenance are key for these vehicles, this information must be collected and considered as much as possible during the approval process.

Car sharing is also an important element in the elimination of private vehicles. As carsharing services expand, the fleet should rely on electric drives. Special carsharing-only parking spaces should be dedicated at the expense of open-access parking.

Municipal administrations should help make mobility services available outside of the city centers and closely connect them to public transportation (PT) services for synergies. In particular, expanding on-demand ridepooling and (e-)bike sharing are suitable tools to connect residents of rural areas to public transport axes. On-demand ridepooling should only be offered where there is no public transit option available. To simplify changing between modes, mobility services should be bundled at mobility stations (at public transport nodes and in residential neighborhoods). These transfer points are even more appealing when they are equipped with additional services (such as parcel boxes, shopping facilities, ATMs).

Ridesharing services, sharing rides in private vehicles (such as Blablacar), and peer-to-peer sharing, i.e., short-term rentals of private vehicles, are particularly eco-friendly mobility options and should be integrated into the platforms.[2]

Another way to encourage eco-friendly mobility modes is to provide greater transparency about the CO_2 emissions of different options, either by displaying them next to the price, or by allowing users to filter by time-to-CO_2 ratios. From an environmental perspective, flight connections should not be integrated into MaaS platforms to make air travel comparatively less convenient.

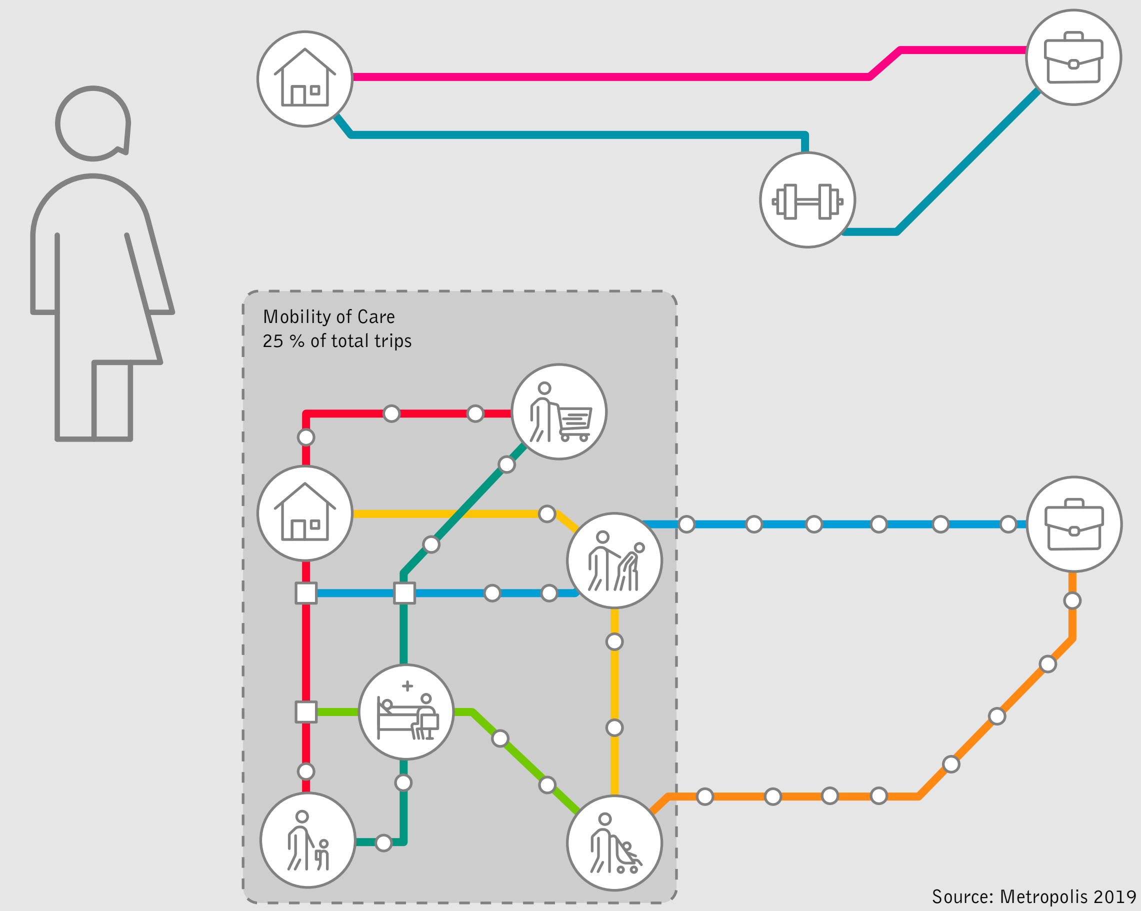
Taking these aspects into account, networked mobility services are one of the few promising approaches that could help transform our mobility system towards shared and sustainable mobility.

2 The OMI project, for example, offers peer-to-peer sharing via a software that enables municipalities, companies, and private individuals to offer their own vehicles for sharing.

2.2 Mobility and gender

"Gender" does not refer to a person's biological sex, but rather their social gender. The term refers to culturally shaped roles that also have a clear impact on the routes traveled in everyday life. After all, today's transportation infrastructure was mostly designed by male mobility planners and decisionmakers with full-time jobs. To them, getting around quickly by car is more important than a dense public transit network and public spaces where children and the elderly can get around safely and independently. This structural imbalance of power between the interests of those in gainful employment and those doing care work has long been analyzed under the term "androcentrism" (see, e.g., Spitzner et al. 2020, pp. 13-14, 17). Other factors that cause variations in mobility behavior include the greater threat level that women and non-heteronormative people face in public spaces[3], different perceptions of risk in traffic, and differences in disposable income (gender pay gap)(Rambol Mobility, 2021, p. 10).

Fig. 2: Gender lenses on mobility



Source: Metropolis 2019

3 The threat of sexual or physical aggression is higher at night and in places or vehicles with no third-party witnesses.

Both women and men use digital technologies for their mobility – albeit in different ways. While women use public transportation more often than men, men use the technology more often than women for routing in private cars as well as for micromobility (Rambol Mobility 2021, p. 12). One reason for this is the fact that care work (e.g. looking after children and relatives, household chores) is still mostly performed by women. In daily life, this kind of care work involves a number of short trips – first to daycare, then to work, to the supermarket, to the children's sports, and back home – rather than one trip straight to the workplace and back (Koska et al. 2020, pp. 116f; see also Figure 2). They often accompany children (or senior citizens) whose mobility is limited. Other times, they carry groceries or other purchases. This poses special demands on the means of transport and infrastructure used. In addition, many women perform both gainful and care work, often resulting in busy schedules and high stress levels.

Cars lend themselves very well to these kinds of mobility requirements. However, car-based mobility also counteracts gender-equitable mobility, which relies on a safe environment in which dependents can move around independently of their caretakers as much as possible, or in which it is easy to accompany them. So in addition to reducing the number of and curbing the speed of cars, increasing mobility options can also ensure greater gender equity. It is important that the offered services facilitate the transport of people as well as cargo, and that they can also be used independently by people with limited mobility.

In their current form, micromobility services such as e-trekking and bike sharing are neither suitable for transporting children and purchases nor for unaccompanied trips by children and mobility-impaired persons. On-demand ridepooling and ridehailing services, on the other hand, often offer pickup close to home and accessible vehicles. That means that they can provide large mobility gains for mobility-impaired individuals and relieve their caretakers.

Mobility services should therefore address different needs: Shared bikes should be suitable for carrying cargo; cabs and on-demand ridepooling should be able to transport children and walking-impaired people by training their drivers and by affording enough time to serve these extra needs. To promote equality in the mobility sector, we need easily accessible, spatially compact transfer points where women feel safe thanks to social control (e.g. presence of third-party witnesses) (Rambol Mobility 2021). One starting point is the concept of mobile stations that are safe and convenient to use thanks to the services they offer and convenient transfer options, offering a variety of mobility options for different needs. When planning such stations, public services such as hospitals, kindergartens, medical centers, supermarkets, etc. should be well integrated as key elements to establish and expand these systems. To make multi-modal trips easier and cheaper, MaaS platforms should offer mobility budgets. Also, establishing new mobility services should not mean that established services get dismantled.

One challenge remains the lack of diversity at the leadership levels of the transportation sector – a trend that continues on the boards of new Mobility-as-a-Service providers.[4] Women should be better represented in planning mobility services and MaaS platforms to address gendered blind spots and gender-biased transportation planning as described above.

2.3 Services for the mobility-impaired

Both participation in and negative impacts from the current car-oriented transportation system are very unevenly distributed (Hennicke et al. 2021, pp. 123–164). The term to describe this phenomenon, "mobility poverty", refers to a disadvantaged group's reduced ability to reach the places they want to go. The reasons can be a lack of financial means, but also deficient public mobility infrastructures and general public services at the place of residence, or health restrictions. Children, the elderly, the poor, and the impaired are therefore the primary groups affected by mobility poverty (Stark 2017). Regarding digital mobility platforms, there is also a lack of digital skills or of digital end devices.

In Germany, new mobility services do not usually replace existing services (such as cabs), but are created as an addition. Ridehailing is an exception since it puts pressure on the cab market (while also being exempt from taxi services' obligation to transport mobility-impaired people). The same is true for on-demand ridepooling, which also serves as a substitute for flexible forms of public transport on routes and at times with low demand.

Commercial mobility services are usually offered where income and demand are highest – in metropolitan centers with a large number of *POI*s that already offer a wide range of mobility options, anyway (Liao and Correia 2022). They thus put pressure on public transport in its most profitable areas (Kahle 2022, p. 276). Depending on the circumstances, this could lead to a worst-case scenario of eroding public transit services. Commercial mobility services rarely serve remote and rural areas. In addition, mobility services are often more expensive than public transport and thus primarily benefit high-income groups. Individuals who rely on cars only for individual trips may, however, lower their mobility costs by using mobility services (Weber et al. 2020, p. 29).

The case is different for services that are publicly funded or offered by public transport companies, since they have to consider the needs of the general public and often serve both central and peripheral areas (e.g. via bike sharing or on-demand ridepooling). They are also

4 For example, when the MaaS initiative "Mobility inside" by the Association of German Transport Companies (VDV) was launched, nine of the ten representatives of transport associations were read as male. See the VDV's magazine of 29 January 2020, "Mobility inside": App im Praxis-Check, https://www.vdv-dasmagazin.de/story_04_mobility_inside.aspx (accessed on 17 May 2023).

often integrated into the pricing structures of the public transit system and can be used with public transit tickets or at affordable fares. On-demand ridepooling that is publicly funded and integrated into the public transportation structure can significantly increase mobility options for people with physical disabilities.

On many MaaS platforms, passengers can view the current status of certain infrastructures ahead of time, such as escalator outages, allowing people with limited mobility to better plan their journeys. In addition, mobility management can identify connections that are not barrier-free. Publicly funded platforms should be required to display this kind of information and subsidized accordingly. Platforms should also ensure that their information is accessible via multiple senses to accommodate the hearing- or vision-impaired.

Another obstacle for low-income groups might be the smartphone that is required to use such services: Although smartphone ownership has risen sharply across all income strata, limited data volume and older cell phone models that are incompatible with newer apps can be a barrier to accessing mobility services. Another obstacle is the fact that poorer people are also less likely to own credit cards, which are sometimes the required means of payment. Direct debit or online payment can also be a precarious form of payment for many low-income groups since they may be risking an overdraft. People who have no checking account are completely excluded from mainstream digital payment systems. Even tech-savvy users are excluded from using mobility services if they don't want to or cannot use a smartphone and there is no other access option (Kahle 2022, p. 277). Publicly funded systems should therefore include options such as booking by phone as well as prepaid options, including the option to top up one's balance at ticket machines or service centers. Digital systems must be designed for accessibility.

2.4 Data protection: challenges and solutions

Greater amounts of data about the population's movement patterns mean more accurately designed mobility services. Information on both *trajectories* (exact routes) and travelers (e.g., age, gender, income) helps accurately assess the potential of different mobility services in a given location. This serves both the public interest and commercial success.

Users, too, can directly benefit from tracking: Today, many multi-fare and multi-provider booking systems fail over complex revenue sharing negotiations. When routes are precisely, digitally tracked across providers, payments can be allocated to the services that were actually used, which makes it easier to issue the same tickets for multiple companies. Features such as check-in/check-out systems, best-price guarantees or discounts for multiple tickets, and price caps for multiple trips are only feasible when trips can be allocated to individual users.

However, collecting and utilizing this data also entails risks: movement profiles are highly individual, which means users can be rapidly identified and localized, and their movement data provides deep insights into their habits (Primault et al. 2018, pp. 3-6). This data could be misused, for example, to time home break-ins, identify political opponents, and spy on someone's health status and recreational behavior (see Kugoth 2023).

There is a big difference between processing personal and vehicle-related data (Weber et al. 2020, pp. 32-33). Vehicle-related data does not generally pose a threat to data protection. The only scenario where such data could theoretically be used to create (incomplete) movement profiles of individuals would be in low-traffic areas, and only if the vehicle has the same ID at the starting point and the destination. An easy fix to make this data untraceable to individuals would be to simply not transmit vehicle IDs. That would, however, also render the data less useful for optimized supply planning since routes can no longer be tracked. One solution is to add the vehicle ID only to spatially or temporally aggregated datasets. These could be used, for example, to generate *heatmaps* that indicate the intensity of use in a certain space. Sharing this aggregated data with planners or trading it with third parties via intermediaries such as the Mobility Data Space, would preserve data protection for users. Deletion periods can also help anonymize behavior patterns to a certain degree. The following applies to all methods: Stronger anonymization (for example, daily data deletion) leads to greater information loss.

Any processing of personal mobility data (i.e., usage data in combination with personal master data or usage profiles across trips) almost invariably poses an increased risk for users. This is why the European General Data Protection Regulation (GDPR) provides for special protective measures for personal data. Data collection must be in the provider's "legitimate interest" (e.g., internal processing for "product development" or data transfers to other companies for a shared ticketing system). Users must consent to the processing of their data for the specific purpose. In practice, the users' consent is often obtained via general terms and conditions that may be very vague about the purposes of data use. If a user rejects the terms, they cannot use the service. The dominant players on the market may exploit such "all-or-nothing" arrangements (Denker et al. 2017, p. 3).

The GDPR requires mobility service providers to submit their planned data processing steps and consent requests as well as an impact assessment to the respective competent data protection authorities (DPAs) in the EU member states or the German federal states. Since the GDPR does not contain any specific provisions for mobility data, data protection authorities interpret the law differently. That means that the same data processing practice may be approved in one federal state and rejected in another. In addition, DPAs generally do not respond to data processing requests unless they deny them. As a result, data controllers often find themselves in a state of limbo. Sometimes, they decide to refrain from analyzing personal data records altogether.[5]

To create legal certainty, it would make sense to clarify the right way to handle personalized mobility data in the introduction of the German Mobility Data Act (Kugoth 2023). In addition, the DPAs in the federal states should coordinate more closely and should be obligated to respond to requests within a specified period of time. At the very least, there should be a clear regulation who may de-identify personal data, under which circumstances, and what constitutes de-identification.

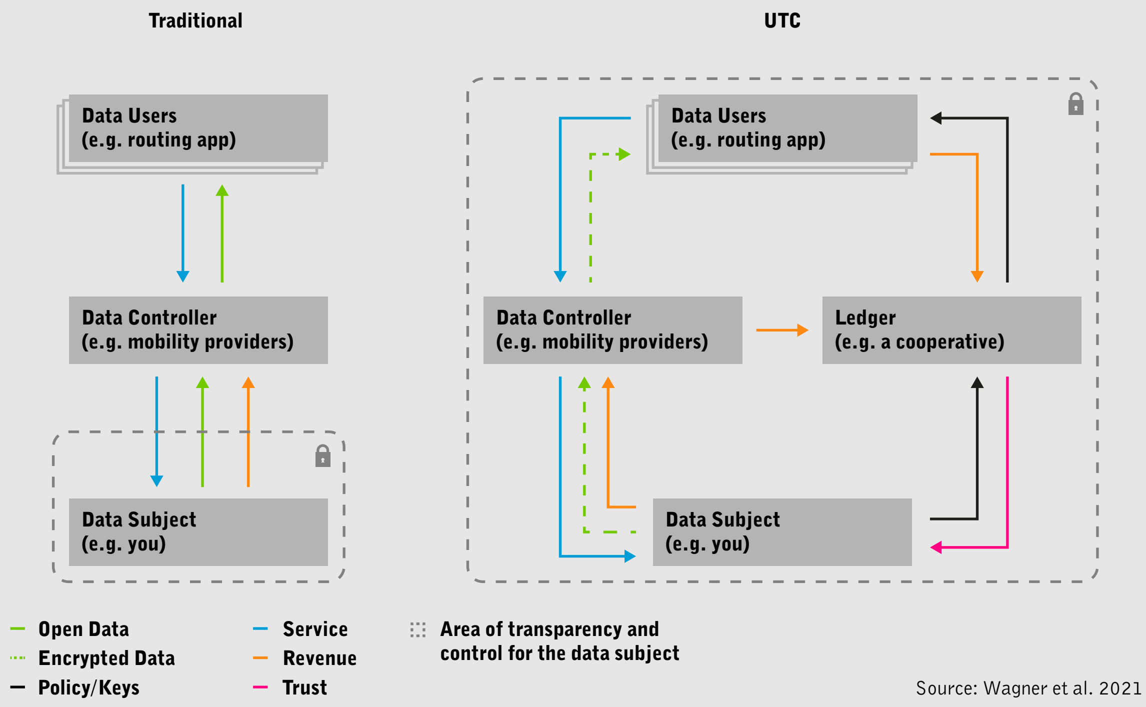
Opinions vary on the question of whether the large-scale use of personal mobility data is even expedient. Some advocate for a minimalist approach that would clearly define the purpose of any mobility data analysis. If this were done early and thoroughly, they argue, raw data could be aggregated spatially and temporally at an early stage and thus anonymized.

Others argue that it is necessary to search the proverbial "haystack of data" to glean new ideas. In order to develop methods that leverage large data sets for new business models without compromising data protection, the German Federal Ministry of Education and Research (BMBF) has funded the research project AnoMoB in the amount of 2.8 million euros. The results are still pending (Frauenhofer IAO 2023). The German federal government also funds research on data anonymization in the projects explanym, IIP, and ANYMOS. A total of more than 10 million euros is being invested in all of the above projects.

Wagner et al. (2021) outline several ways to enable Big Data analysis without violating data protection. In these models, users are given greater control over their own data. One model suggests using intermediary institutions with no financial stake in the data use. To both ensure data protection and promote insights and innovation, they propose user-centered trusts (UCTs) (see Figure 3). In this model, users actively consent to the use of their data for specific purposes for a financial incentive. This approach could be promising, since, according to a study by the digital industry association Bitcom, more than 90 percent of German citizens are generally willing to share data about their mobility (Bitcom 2021).

5 In the stakeholder interview for this report, a project manager responsible for a new on-demand system said that due to such uncertainties, the data "won't be touched at all," since the mere act of pulling data for anonymization purposes could already constitute a breach in his home state.

Fig. 3: Traditional and UTC dataeconomy



Source: Wagner et al. 2021

Given that digitization pervades all areas of life, we should not forget that mobility services are not the only generators of mobility data. Digital companies such as Alphabet, Apple, or Meta, as well as a number of small apps (calendars, weather apps, map services, games, etc.) also request their users' location and can prove their "legitimate interest" in doing so, which makes it lawful to embed user consent to data transfer into the terms and conditions of the service (see above). These datasets are sometimes very comprehensive and could be of great value for transportation planning, since they also imply information about the purpose of the trip (movie theater, work, ...). Many users disclose their data to these providers out of indifference, ignorance, or for lack of viable alternatives, while mobility service providers refrain from processing such data due to reputational risks.

3 MaaS Platforms and Use of Mobility Data by German Municipalities

The legal and organizational framework for MaaS platforms in Germany, as described below, is an important starting point for mobility platform development. We present three case studies to highlight the use of mobility data at the municipal level, as well as the development of mobility platforms.

3.1 General conditions for MaaS platforms in Germany

MaaS platforms bundle the offerings of various mobility service providers. In the past decade, legislation has been passed to encourage this development, especially at the European level, and a large number of players in Germany have been creating new platforms.

3.1.1 Legislation and implementation in the EU and Germany

In Germany and the EU, mobility data is comprehensively regulated, and there are a number of strategy papers on the subject. As early as 2010, the EU laid the foundations for pan-European mobility platforms with its "Directive on the Framework for the Deployment of Intelligent Transport Systems" (ITS Directive). It aims to ensure "the coordinated and coherent deployment and use of Intelligent Transport Systems (ITS) within the Union" (Directive 2010/40/EU, L207/3). This is justified by an overburdened road infrastructure, increasing energy consumption, and the resulting environmental and social problems. The EU legitimizes its action with the principle of subsidiarity, because although there are pertinent activities at other levels, there remains "fragmented and uncoordinated deployment and lack of geographical continuity of ITS services throughout the Union and at its external borders." (Directive 2010/40/EU, L207/1). The ITS Directive essentially stipulates that standards and specifications for intelligent transport systems be harmonized and precisely defined throughout the EU. Even back then, the legislation aimed at sharing mobility data across providers: "ITS should be built on interoperable systems, which are based on open and public standards and available on a non-discriminatory basis to all application and service suppliers and users." (Directive 2010/40/EU, L 207/1). Accordingly, the goal is to create EU-wide MaaS platforms with deep integration.

Building on this, in 2017, the European Union obligated all member states to set up what is called National Access Points (NAPs). Their purpose is to pool data from all scheduled or demand-based modes of transport (road, rail, air, and sharing) (Delegated Regulation (EU) 2017/1926, L 272/2).

In some respects, the regulation is inconsistent: While static data (fare information, schedules, etc.) must be made available in all countries via the NAP, member states are free to choose whether to require NAP submission of dynamic mobility data in their country (such as current delays, location, and availability of sharing vehicles). However, a MaaS platform can only display comprehensive information when it is fed dynamic data. In addition, member states are required to make available certain data between 2019 and 2021, yet they are not subject to any sanctions if they fail to do so. Member states are required to submit a biennial report on their implementation progress to monitor compliance with the Directive.

The most recent report (2020) shows that data from private actors was only available in three countries. The report notes that shared data in Multimodal Transportation Information Systems (MMTIS) is of poor quality, despite available standards. This results, among other things, in inconsistent information, different data attributes, or incomplete data sets (EU-EIP 2021, p. 83).

Currently, the ITS Directive is being revised. NAPCORE (National Access Point Coordination Organisation for Europe) supports this reform, calling for mandatory data submissions that safeguard the rights of users and data providers (NAPCORE 2022).

In addition, the European Commission announced another legislative initiative on multimodal, digital mobility services in its 2022 work program (see Soone 2023). The process has been postponed several times. Currently, an expert group is working on the issue. The EU website on the subject shows no progress.

In Germany, the NAP was established by the Intelligent Transport Systems Act (IVSG). It is hosted by the Federal Highway Research Institute (Bundesanstalt für Straßenwesen). The first data delivery requirements were introduced in 2021, including both static and dynamic data. Since they were anchored in the Passenger Transportation Act (Personenbeförderungsgesetz), only providers of scheduled and non-scheduled transportation[6] are currently required to provide data to the NAP. Mobility services that are not regulated by the law, e.g., sharing services and rail passenger transport, are currently not required to submit any data. Therefore, for example, Uber (as a "non-scheduled service") is obligated to submit data, but TIER (as a micromobility provider) is not. Providers of scheduled and non-scheduled transport services and others are therefore critical of this unequal treatment of comparable mobility services. Also, there is no sanction for failing to meet one's data submission obligations. One year after all scheduled and non-scheduled providers were supposed to transmit their data to the NAP, the percentage of providers that are actually transmitting data remains negligibly small. In one of the interviews, a process participant familiar with the situation spoke of participation in the "per mille range". The law is thus a "toothless tiger".

6 Scheduled and non-scheduled transport includes transport by bus, tram, or paid motor vehicle rides. Non-scheduled services are transports without a fixed timetable (e.g. cabs).

Box 2: German and EU approaches to mobility data and digital mobility services

Fig. 4: EU level, laws, and projects for mobility data

Strategies	**European Data Strategy** – Aims to create one single internal data market – Use is to be based on fair, viable, and clear rules	**Sustainable and Smart Mobility Strategy** – Aims to provide intermodal mobility services across acountries – Part of the Green Deal, describes roadmap towardds a 90% CO_2 reduction in the traffic sector by 2050, thus giving states and coporations as a timeline – Names 10 focus areas, among them automated mobility and collective travel
Laws	**Data Governance Act** – Defines the foundations to establish reliable data trustees that will be able to pool and share even sensitive data – Basis of the "European Data Spaces"	**Data Act** – Establishes a framework of rules to govern data sharing between corporations and public entities – Is also an attempt to regulate developments such as the IoT and machine-generated data – Will fundamentally change data regulations, also with regard to copyright and trade secrets
	Artifical Intelligence Act – Regulates the use of AI (broadly defined, including machine learning and statistical estimating methods) for commercial and scientific purposes – Prohibits and regulates AI applications that impact human activity or could lead to discrimination – Addresses AI developers	**Digital Markets Act (DMA)** – Is part of competition law, targets platforms that occupy dominant market positions of the patform economy in various EU states – Aims to prevent the vertical integration of several key technologies by just one actor
Projects	**Research funding** – Such as Horizon Europe	**Common Mobility Data Space** – Serves to store and process mobility data as a federally organized, energy efficient, and reliable cloud – Will rely on data formats and pocesses that can be aggregated by linking them with data sets from other Common European Data Spaces

Fig. 5: National level in Germany, laws, and regulations relevant to mobility data

Strategies	**Digital Strategy Germany** – 18 "beacon" projects from all Federal Ministries – All German traffic data is to be made accessible and usable	**Data Strategy Germany** – 4 fields of action: high-performing data infrastructure, promote responsible data use, as well as data culture and competition, have the state take the lead – Comprises approx. 240 single measures

<table>
<tr><td rowspan="2">Laws</td><td colspan="3">Law on Intelligent Traffic Systems (IVS-G)
– Refers to systems that leverage information and communication technologies in road traffic and at interfaces with other traffic carriers</td><td colspan="3">Passenger Transport Law
– Reform in 2021 implemented the requirements of the IVS Directive to submit static and dynamic data to the NAP
– Incorporates mobility service providers and multimodal traffic information providers into passenger transport law</td></tr>
<tr><td colspan="3">Law on Mobility Data
– Is currently in the stakeholder dialog phase, first recommendation paper to be published soon</td><td colspan="3">Mobility Data Directive
– Defines standards for transmission paths and data formats for data from scheduled and non-scheduled transportation to the NAP</td></tr>
<tr><td>Projects</td><td colspan="2">Mobilithek
– Free public service funded by the BMDV
– Central data pool for public open mobility data
– NAP to which mobility service providers are obligated to submit their data according to the PBefG</td><td colspan="2">Mobility Data Space (MDS)
– BMDV-funded non-profit organization in which public and corporate actors cooperate
– Aims to enable commercial exchange of mobility data, thus facilitating data driven business models</td><td colspan="2">Promoting digitization in the traffic sector
– Research and development projects via MFund
– Broad implementation by issuing a call for tenders for "Digitization of community traffic systems"</td></tr>
</table>

A new Mobility Data Act is currently being prepared by the Federal Ministry of Digitalization and Transport (BMDV). To be adopted in 2024, the law will promote the provision and best use of mobility data across all modes of transport. The draft has not yet been published, and no specifics are known about its content. This legislation could bring Germany closer to fulfilling the purpose of the ITS Directive, which is to create fair competitive conditions in the mobility sector by obligating all mobility service providers to submit their static and dynamic data. In addition, this legislation could significantly boost data submissions to the NAP by introducing penalties for non-compliance.

Municipalities also have a certain power to compel mobility service providers to submit data or integrate with MaaS platforms. However, their possibilities vary widely according to the type of service, and they depend on laws and regulations at different levels of the federal system. Municipalities' ability to leverage special-use regulations to require free-floating bike and e-scooter sharing providers to submit data to them or to integrate into a MaaS platform depends on whether they are classified as general sharing services or if they fall under special use permits. Since this is not clearly regulated by federal law, municipalities, federal states, and administrative courts interpret this differently. In the case of station-based carsharing, many municipalities are able to include such obligations in the evaluation matrix that is the basis for allocating carsharing parking spaces.

So while the strategic goal of intermodal mobility platforms is clearly defined at the EU level, the current regulatory framework in Germany remains fragmented and does not offer a good basis for comprehensive MaaS platforms to emerge.

3.1.2 MaaS platforms in Germany

A large number of private and publicly funded MaaS platforms are already available in Germany today. Piétron et al. (2021, pp. 21-22) provide a fairly recent overview.

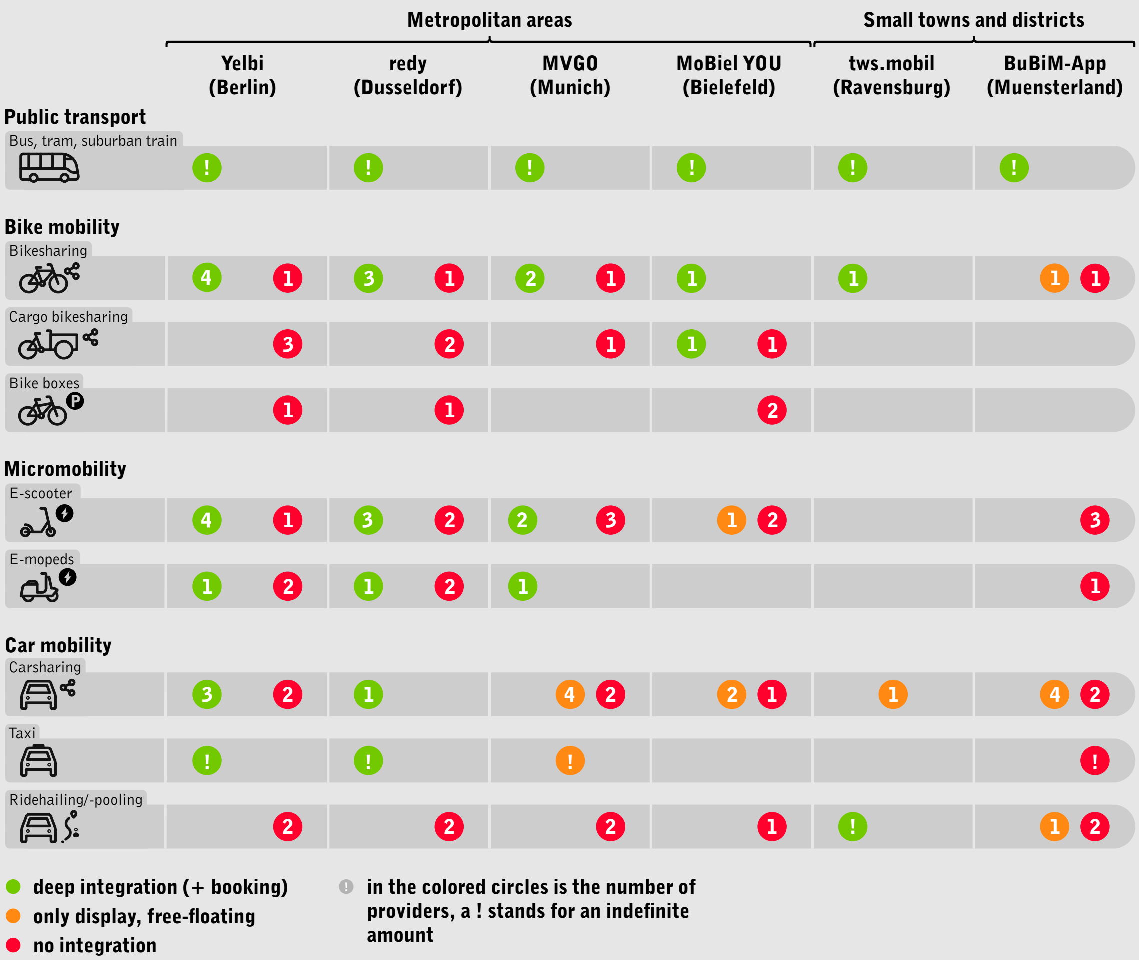
Private MaaS platforms are mostly provided by map services (e.g. Google Maps), original mobility service providers (such as Uber), or automotive companies (e.g. ShareNow by BMW and Daimler). These commercial players coordinate at the corporate level and often follow the expansion logic of the platform industry. Relying on international cooperation, they build a large customer base and are often able to gain a dominant market position thanks to customers' reluctance to use multiple platforms and particularly strong economies of scale. Once they attain dominance, platform operators often restrict data access for mobility service providers, hike up fees, and systematically circumvent tax and labor laws (Piétron et al., 2021, p. 10).

But publicly funded actors are also gaining traction in this area, either developing their own platforms or using *white-label* platforms from software companies. In the latter case, the platform provider usually deploys the user interface and the backend (e.g., API interfaces for data processing), while the public sector entity, like a municipality or a transport company, serves as coordinator, recruiting mobility service providers for integration. The user interface is usually branded for the public transport company or association that commissioned the platform.
This strengthens the brands of public transport companies since the public perceives the platform as their offer. The strategic advantage of such MaaS platforms is that they are closely connected with municipalities that can use their regulatory powers (e.g., special-use regulations[7]) to advance the integration of private mobility service providers into the apps of public transportation companies. Figure 6 provides an example of the scope and depth of integration of local transportation services in some metropolitan areas as well as small cities and districts.

However, the local approach also has disadvantages. Publicly funded actors are concurrently working on similar projects in many places and at different levels – often with financial support from several different sources of public funds. One example is grants for integrating check-in/check-out systems in a variety of publicly funded, local, and regional public transport (PT) booking platforms (see BMDV 2022). Many of these solutions are only available locally and legacy systems persist even after MaaS applications spanning multiple companies and transport associations are established.

7 Special-use regulations are enacted by municipal bodies based on state law. They regulate the requirements that apply when road space is used in "excess of common use".

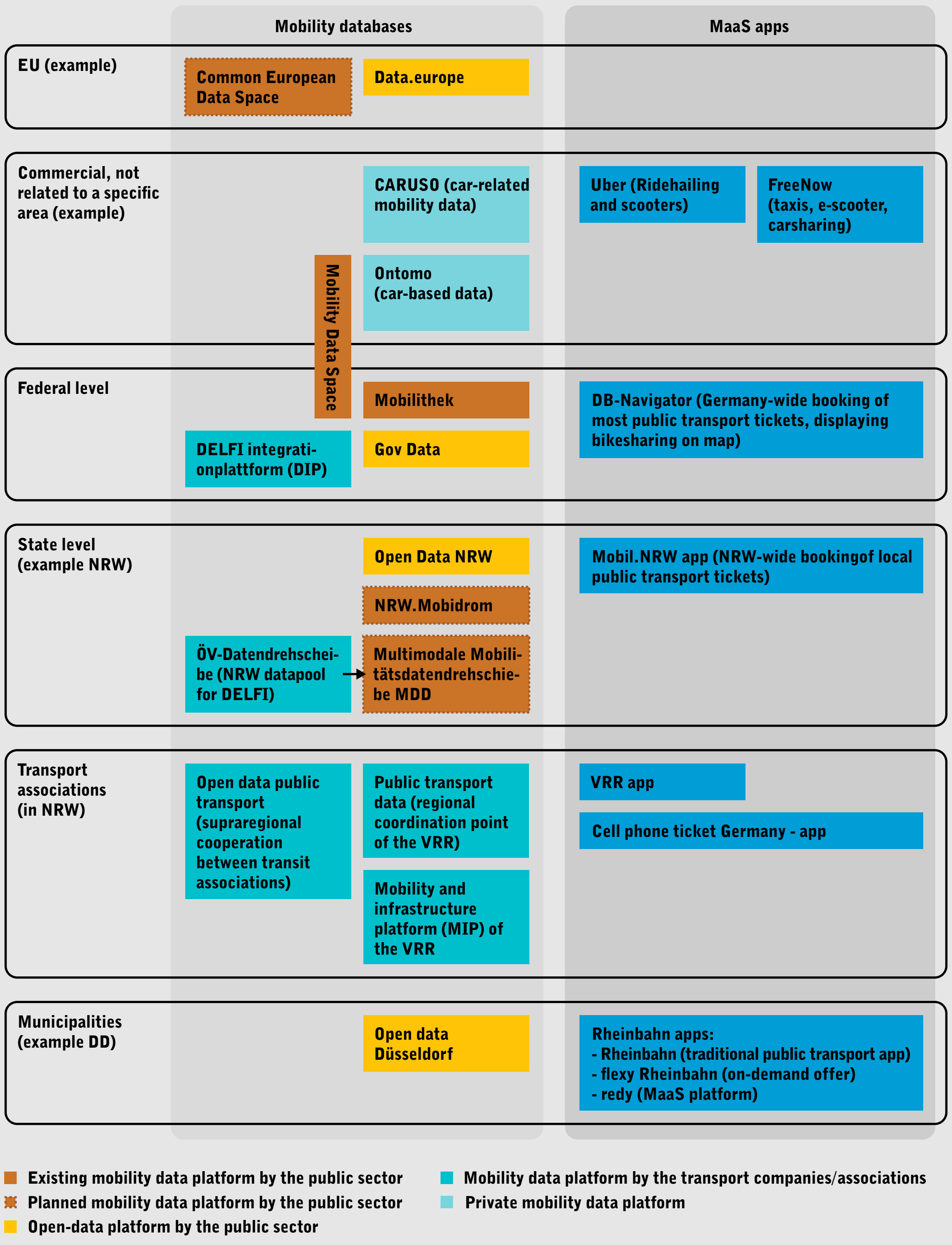
Fig. 6: Comparison of selected MaaS platforms



Traditionally, providers have been thinking within the boundaries of transport companies and transport associations. That means that there is no information and booking platform for public transport that could be used statewide or nationwide and could integrate other mobility services. Many local players rely on their own platform to control functionality and strengthen their brand. The example of Düsseldorf in Figure 7 shows how many MaaS platforms are available in a single city to view or book public transport mobility services. This is similar to multiple public sector entities building parallel mobility databases or platforms, which are also shown in Figure 7.

Many places maintain several platforms at different levels serving the same purpose. While local platforms can better adapt to local conditions, their maturity level and functionality fall far short of what an overarching development could provide. In addition, every system that is newly or further developed ties up financial and human resources. This situation is due to a variety of stakeholders pursuing their own interests.

Fig. 7: Mobility data infrastructure and MaaS platforms with a focus on Düsseldorf



3.1.3 Interests of private and state actors and platform operators

Currently, each household spends around 266 € per month on cars, buses, trains, and the like – 233 € of which is spent on car mobility (DESTATIS 2019). Since mobility services become more attractive when the various offerings are better interconnected, there are strong economic incentives for progress in this area that apply to the entire sector. However, the various actors hold widely varying perspectives, and they are all trying to protect their own interests (Maas 2022, p. 14). The following is a brief outline of the interests of private and public transport companies as well as MaaS platform providers.[8]

The interests of public transport companies and of transport associations

For any mobility service provider, a direct customer relationship is essential since it enables them to publicize their own brand and build customer loyalty. Good client relations allow providers to display targeted advertising or place special offers. The Association of German Transport Companies (Verband Deutscher Verkehrsunternehmen, VDV) emphasized this aspect in a position paper on flexible forms of service. To guarantee these options, "transport companies and associations [...] should cooperate with manufacturers or integrate the offer into their own product range."(VDV 2015) Mobility inside is the VDV's own MaaS platform development, funded by the German government. It is available as a white-label product for public transport companies. However, it currently only offers nationwide and multimodal routing; bookings are still made in the providers' apps (Mobility inside 2023).

International corporations in the platform economy have vast experience in analyzing large data sets and designing intuitive and functional user interfaces. Public transit system operators are concerned that they may lose their own market position and freedom to design their own offerings if more and more customers obtain public transport services via third-party apps and displaying services in their apps becomes a relevant sales factor.

Every company or alliance also has an interest in self-preservation. If more and more tickets are sold via third-party channels, their own pricing and marketing departments would become redundant. Management, too, would lose key control options.

Industry experts also note that it is currently difficult to compare how efficiently publicly funded transport companies are using such funds. A database that is public or accessible to government stakeholders and researchers could put considerable pressure on inefficient companies by exposing their poor performance with regard to delays, facilities at their stops, etc. From an industry perspective, this would be a case against enforcing an obligation to provide data. On the other hand, public transport companies and associations – unlike providers of sharing services – are already obligated to supply data. They might also favor extending this obligation to other mobility service providers because it would create equal and fair conditions.

8 The field of MaaS players is crowded. For an overview, see Kamargianni and Matyas (2017).

Interests of commercial mobility service providers

It is a challenge to accurately render the interests of this highly diverse group of actors (see Wolking 2021, p. 127). Also, their positions greatly depend on the type of platform into which they could integrate their services:

Box 3: Different MaaS platforms

Scenario 1: The "Finnish model" (see chapter 4.1)

- Platform enables access to all mobility services
- Platform displays all services of a given type without discrimination

Scenario 2: Commercial platform in the status quo

- Platform cooperates only with some mobility service providers
- Displays only their offers.

In the status quo scenario (scenario 2), platform providers seek to achieve a high level of market coverage by integrating the largest possible number of providers of each form of mobility. These mobility service providers will then be essential for the success of the platform and may thus be able to persuade platform operators to exclude smaller competitors offering similar services, keeping their competitive pressure low. If, for example, Google Maps were to become a convenient one-stop shop for mobility services by collaborating with mobility market leaders such as Uber (for ridehailing), TIER (including the Nextbike fleet, for (e-)bike and e-scooter sharing), and ShareNow (for carsharing), competitors would face significant challenges. Dominant players would become even stronger, and a monopoly/oligopoly would likely form in parts of the market. Public transport companies would probably have little incentive to participate in such a system due to their weak market exposure combined with their strong market position and strong interest in brand preservation. They could therefore introduce or maintain their own platforms and include smaller commercial or publicly funded sharing, on-demand ridepooling, and similar mobility services.

Scenario 1 would lead to a different situation, since it would establish a data pool that is fed by dynamic data from all actors. Platform operators could book third-party offers at retail prices via a payment interface as long as they display all offers available in the data pool. In such a market situation, all players – whether small or large, new or established – would be displayed on the emerging MaaS platforms that include all providers. Of course, there would also be room for selective platforms coexisting outside of this system, with their own special offers, mobility budgets, etc. However, they would not result in a monopolization of the markets, since the mobility services offered on such selective platforms would also be available for booking on the non-discriminatory platforms, and MaaS platforms and mobility service providers would have much less market power.

The German federal association Bundesverband Carsharing (2018) emphasizes that all providers of a certain mobility service should be displayed without discrimination. It does point out a risk, however: When customers access services via a platform that does not establish a direct link between customers and service providers, they might not handle the vehicles with sufficient care. The association also feels that customer satisfaction may be compromised if support is handled by a central entity with little experience with the individual offerings.

Scenario 1 could spur significant innovation as start-up mobility service providers could cater to a broad customer base as soon as they enter the market. For example, a cargo bike sharing system that serves only part of a major city, but deploys a large fleet, would appear directly on the end devices of most residents in that neighborhood. This would draw attention to the offer without a need for advertising. The booking would be handled via the user's standard mobility app, which is convenient for users and saves resources for the startup. In this scenario, however, the roles and responsibilities of platform operators and service providers regarding service, customer contact, and revenue sharing remain very unclear (see Ydersbond et al. 2020, pp. 138-139).

Interests of private MaaS platform operators

The current situation holds several advantages for white-label platform providers. On the one hand, they can sell their software to an ever-greater number of customers who are building local or national platforms. On the other hand, many of these customers want to see specific features on the platform. This comes at an extra cost – but the platform provider can then also market these features to other customers. Scenario 2, market monopolization by proprietary platforms, would be unfavorable for operators, since one commercial platform would handle a large portion of the sales. However, if the business volume with public mobility providers remains the same, they could retain a wide variety of customers. Establishing a non-discriminatory data pool (scenario 1) would lessen dependence on dominant players but intensify competition between MaaS platforms. In this case, it would be interesting to develop innovative business models, such as data analyses for third parties or mobility budgets, in cooperation with mobility service providers.

3.2 Mobility management: Case studies from German municipalities

Municipal mobility management resources vary greatly depending on the municipalities' size and financial strength. In the following, we will show three examples of how various German cities use data in their mobility management, what approaches could be taken in the future, and how they address the issue of MaaS platforms. The content is based on interviews with representatives of the municipalities mentioned.

3.2.1 Troisdorf

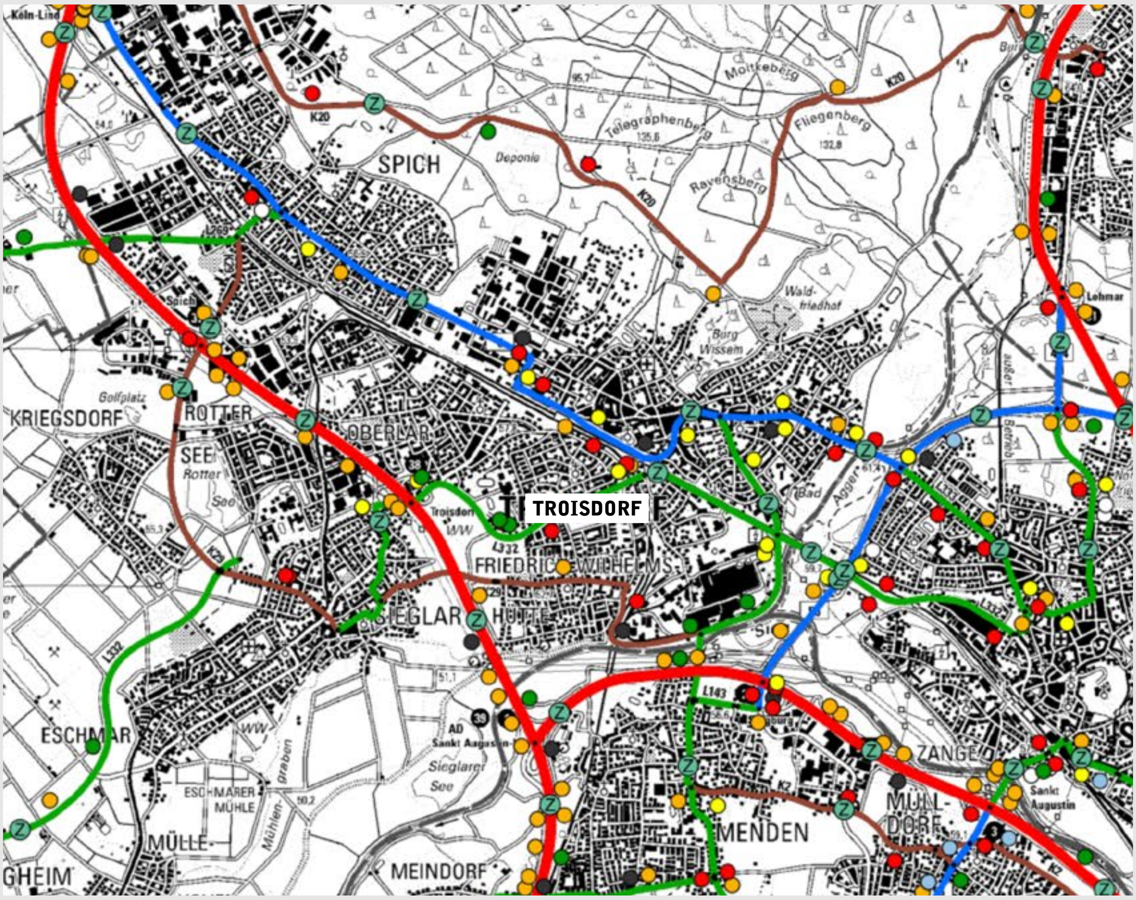
Troisdorf is a city in the Rhein-Sieg district in North Rhine-Westphalia with about 78,000 inhabitants. Its transportation planning department has three staff positions that handle a wide range of tasks related to public transit, transportation planning, and mobility management and services.

Municipal mobility management using mobility data

At present, the residents' mobility is surveyed primarily by sporadic traffic counts using underground induction loops as well as mobile devices and the information system of "Straßen.NRW" (see Figure 8). These measures offer insights about the volume of bike and car traffic on main axes or at special counting points, but reveal nothing about starting points and destinations. Every 7 to 8 years, Troisdorf conducts a survey on the modal split as well as on the residents' level of awareness of available transport options. 80 percent of the data is collected by the "Arbeitsgemeinschaft fußgänger- und fahrradfreundlicher Städte, Gemeinden und Kreise in Nordrhein-Westfalen e.V." (Work Group of Pedestrian- and Bicycle-Friendly Cities, Communities and Districts in North Rhine-Westphalia, or AGFS NRW).

There are no precise insights into routes and means of transport used, even though this kind of data would help identify opportunities for shifting traffic away from motorized private transport (MIV) to public transport and to optimally position offerings such as mobile stations or Park&Ride facilities. The *Pendleratlas* (Commuters' Atlas) provides some information on commuting patterns across municipalities. However, this is based on residential and work locations, not the actual routes traveled. Some time ago, the city considered using mobile data and purchasing analytical tools, but they ended up dropping this plan because at the time, the data was not spatially precise enough.

Fig. 8: View of the Road Information Bank of North Rhine-Westphalia (NWSIB)



Interstate
State highway
Country road
County road
Counting point (Z)
Driving accident
Turning accident
Turning/crossing accident
Accident involving a crossing pedestrian
Accident in stationary traffic
Accident in longitudinal traffic
Other accident

Source: www.nwsib-online.nrw.de

After an initial surge of micromobility providers, only TIER and Nextbike remain active in Troisdorf. Troisdorf only has data on station-based usage of sharing providers. The city could request more accurate data but does not have enough staff to even fully exploit the providers' dashboard innformation. They do not pull any data from their public transit system because the planning is done at the district level. There is no data on cabs or car-sharing.

Despite externally funded household surveys, the data basis is currently insufficient to obtain a complete picture of the population's mobility and to conduct optimal supply and transport planning. In addition, the available data is scattered across different systems. This is why the city of Troisdorf is currently channeling the funding program "*Digitalisierung Kommunaler Verkehrssysteme*" to procure a traffic model that will consolidate existing "data sinks". This simulation model will help plan infrastructure projects and also make it possible to analyze ecological aspects. For example, it can estimate the change in

CO_2 emissions from traffic as infrastructures or speeds change. The data will also be processed for use in a public traffic dashboard as part of the *Smart City Strategy*, which is implemented in cooperation with the department for digitization.

Local MaaS platform

Currently, there is no local MaaS app. When Troisdorf introduced e-scooters, they considered integrating other mobility services into their e-carsharing app MOQO, thus establishing a MaaS platform, but wanted to first observe how e-scooters would develop. Now the city is considering integrating MaaS into the Smart City app. In this context, it is also monitoring the development of the statewide public transport app mobil.NRW. At present, there are no active plans to integrate mobility service providers into such a platform.

3.2.2 Düsseldorf

As a large city with a population of about 620,000, Düsseldorf has an Office for Traffic Management with departments for planning, regulation, and strategy development (Landeshauptstadt Düsseldorf 2023). In addition to the city-owned public transport company Rheinbahn AG, a municipal company called Connected Mobility Düsseldorf (CMD) was founded in 2020. Its focus is on physically integrating various mobility services by pooling them at mobility stations, as well as on Big Data and other aspects of digitization (Landeshauptstadt Düsseldorf 2020).

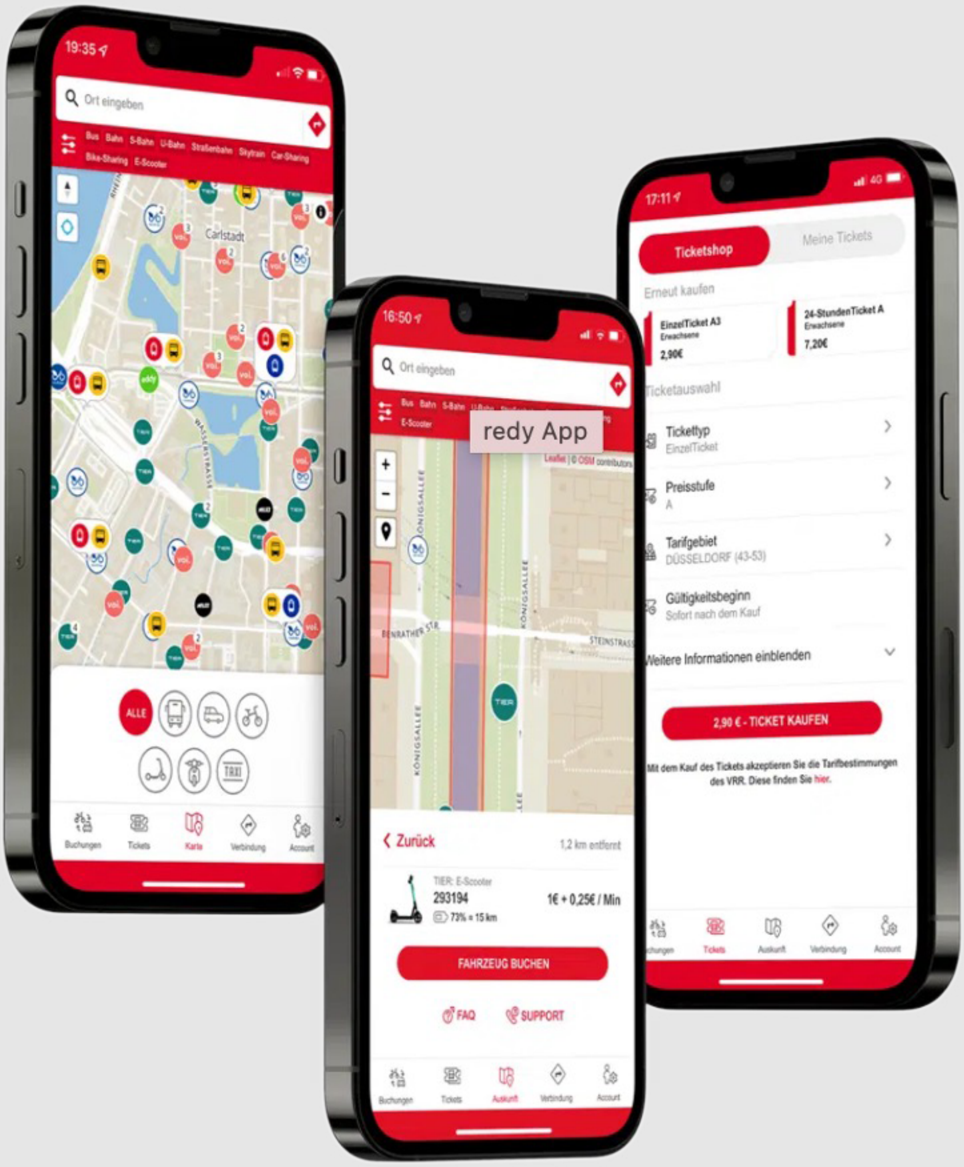
Municipal mobility management using mobility data

In Düsseldorf, too, the main tools for mobility planning consist of data from SRV household surveys (currently from 2018) as well as stationary and mobile traffic counts. These counts mainly capture passenger car traffic on major axes. The survey of bicycle traffic is currently being expanded. Using SRV data ($n \approx 8,200$), the modal split and purposes of trips can be traced for three types of spaces (downtown, busy locations, less busy locations). This data feeds an urban, multimodal transport model that includes MIV, public transport, walking, cycling, and commercial transport. It lends itself well for planning newly built neighborhoods or for other infrastructure proejcts; it is less suitable for estimating behavioral changes, e.g., caused by new mobile stations or evaluating the introduction of the nationwide Deutschlandticket. Commuting patterns with the surrounding area can also be mapped to some extent, but they are currently not accurately captured by any entity.

The CMD processes data from e-scooter sharing, e-bikes, and e-scooters in a dashboard that displays utilization rates, locations, and local start-endpoint connections. In the future, the dashboard will also include carsharing and ridehailing. In theory, there is also public transport data from sources such as their local MaaS platform redy, including the future on-demand ridepooling service flexy. However, this data is currently primarily used by Rheinbahn, Düsseldorf›s public transport system. Data from cab providers is not available.

An ideal base for mobility development would be a comprehensive overview of start and endpoints, including trip purposes and modes of transportation used. To this end, discussions were held with several companies that indicated they could provide such data sets. On closer inspection, however, these data sets were often either highly spatially aggregated or too ambiguous regarding the precise means of transport or the representativeness of the population.

Fig. 9: Views of the Rheinbahn mobility platform redy



Source: https://www.rheinbahn.de/fahren/mehr-mobilitaet/redy-app

Local MaaS platform

The idea to build an intermodal mobility platform came up as early as 2017. As the old Rheinbahn app was phased out, a cross-modal platform modelled after Vienna, Austria, was procured in a joint effort by the city, Rheinbahn, and CMD (see Figure 9). Now they are working to gradually integrate more offerings into the platform. They consider their customer base and the reputation of the Rheinbahn public transport company important levers for integration. So far, private mobility service providers have shown interest in integration, but in practice, limited staff resources are an obstacle. The city is confident that it will be able to establish further collaborations if the Rheinbahn app redy is well received by customers. Providing data and integration into the redy app are also prerequisites for obtaining a special-use permit for e-scooter and bike sharing in Düsseldorf. The city is also considering incentives, such as covering part of the cost of platform integration or running joint advertising campaigns. The city sees itself as a coordinator that lays the groundwork for integrating more services into the app via tenders and special-use permits, while Rheinbahn has expertise in technical aspects.

3.2.3 Munich

With a population of around 1.5 million, the Bavarian capital is Germany's third-largest city. In addition to municipal departments for construction, urban planning, and climate protection, it has an independent mobility unit with ten specialists working on mobility data. In addition, the Munich Transport Association (Münchner Verkehrs- und Tarifverbund) and the municipal Munich Transport Company (Münchner Verkehrsgesellschaft) are engaged in an expert exchange on mobility data.

Municipal mobility management using mobility data

In Munich, too, traffic counts continue to be a key data source. About one hundred of their several hundred permanent automobile counting stations are able to distinguish nine different types of vehicles. There are currently six permanent bicycle counting stations. Mobile manual counts can be added at short notice. In addition, cameras are used to detect pedestrians and danger spots. Approximately 90 percent of public transport vehicles (buses, trams, subways, and commuter trains) are equipped with automatic passenger counting systems that record boardings and exits. In addition, household surveys are conducted as part of the "System of Representative Transport Surveys" (SrV, n≈40,000). All of this data feeds a traffic model that has just been expanded to contain approximately 1,200 traffic cells, now also including bicycle traffic. Changes in mobility modes can now also be mapped. A city-owned mobility panel is currently being developed in order to obtain more up-to-date data. Approximately 4,000 people will be regularly surveyed about their mobility behavior.

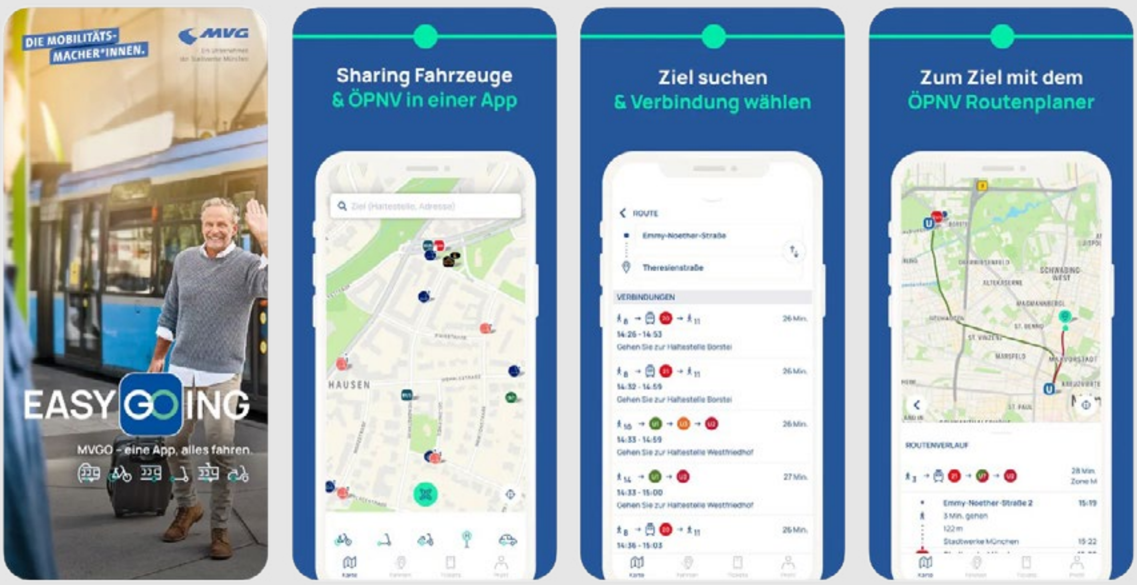
Carsharing and micromobility providers submit data on start-endpoint connections and fleet utilization (bike, scooter, and carsharing, as well as sales in the check-in/check-out system *eTarif*). Companies are eager to cooperate, and agreements are secured via cooperation contracts and voluntary commitments during the approval process. At present, the various data sets are not yet centralized, but they are blended depending on the issue at hand; a central monitoring system is currently being set up.

The city administration is in dialog with companies that sell data from mobile or routing applications and occasionally purchases data from them. However, the movement profiles from this data don't offer reliable insights into traffic modes. This could be solved by accessing device sensors: Cell phone gyroscopes emit different signals depending on different vibration patterns and are even able to distinguish between subways and commuter trains. This is where Munich is getting creative: With about 2,000 volunteers who consented to using their sensors for an analysis of their mobility behavior, the Oktoberfest app was able to collect data on the users' routes, including the modes of transport they took. Talks with Google about their vast data sets have so far been fruitless. Google does not currently sell this data, but makes portions of it available on dashboards.

Local MaaS platform

As MVG's digital sales and information channel, MVGO is the central mobility app of the Munich transport company (see Figure 10). It connects public transport and shared mobility services (bikes, e-scooters, and carsharing) across Munich, also offering cell phone tickets, connection information, and live departure times. The app is being developed further in cooperation with the mobility department of the City of Munich. Munich makes contracts with mobility service providers to support the integration of new providers into the MVGO app. The aim is to include information on all mobility services in Munich.

Fig. 10: Views of the MVG app MVGO



Source: https://www.mvg.de/services/mobile-services/mvgo.html

3.2.4 Summary of findings

Based on our analysis of practical examples, a literature review, and interviews with stakeholders, we come to the following conclusion:

- While large cities have skilled staff to acquire and analyze mobility data, small cities have to tackle these tasks with small teams that often lack the right skills. Attracting skilled personnel is a major challenge in all municipalities.
- Currently, there is a lack of comprehensive, yet precisely localized information on the population's mobility that would allow for optimal placement of services and that could serve as a basis to determine the impact of measures such as a new mobile station.
- Establishing new municipal subsidiaries for digital mobility and Mobility-as-a-Service (MaaS) can help municipalities harness the potential of mobility data. As publicly funded actors, such subsidiaries can pool skills and opportunities for MaaS alongside public transport companies and city administrations by tackling the physical and digital integration of mobility services together as one overarching endeavor. Systems with agile structures are able to develop projects rapidly, recruit motivated employees, and develop digital skills.
- There are various levers for integrating different mobility services into the MaaS platform depending on how a service is approved. The strategy for comprehensive local integration is currently two-pronged: accommodate mobility service providers and exert a certain amount of pressure on them, for example by imposing data submission requirements for special-use permits.
- None of the municipalities expressed any current concerns about data protection and its challenges. This is because their data collections are either vehicle-related or the survey providers remove personal data before they transmit the data. Any data sets that are shared outside of the city administration are usually green-lighted by a data protection officer. No uncertainties or special efforts are reported.

4 Proposals for Comprehensive MaaS Platforms and Optimizing Mobility Services

The goal of ecological, fairer mobility cannot be achieved by simply changing the drives of private vehicles. What we need is a shift from motorized individual transport to the larger ecological network (walking, cycling, public transport, and other mobility services). Consistent legislation and support for municipal mobility management can help this transition succeed.

4.1 Targeted support for sustainable MaaS applications

Easy-to-use (easy access and bundled payment) mobility services on one or more MaaS platforms can significantly reduce use barriers (*Rube et al*. 2020, p. 28). This will increase demand for mobility services and improve their linkage with walking and cycling. For this purpose, platforms should offer deep integration, i.e., in addition to providing information about various options, they should also be able to handle booking, payment and, if necessary, activation. To make car-free living a feasible option, this should include all transportation services (except air travel and, from an environmental perspective, perhaps also non-pooled ridehailing). Beyond the options that are usually integrated in today's MaaS platforms, coaches, ridesharing (e.g., blablacar), bicycle parking, or commuting platforms (e.g., Pendla, a platform open to all municipalities) could also be considered. Opportunities to integrate peer-to-peer sharing systems should be explored.

Since many people in Germany travel in different places and across regional boundaries, a nationwide solution would be desirable. This would require either forming an alliance of all, or at least an overwhelming proportion of, mobility service providers; barring that, legislative intervention in the market would be required. Experience shows that a voluntary alliance is unlikely: Even the merger of public transport companies into larger transport associations was a complex, lengthy process that did not lead to nationwide integration (see Büchler 2021). Examples of successful integration of private services into one platform are hard to find.

The EU clearly stated its goal of pan-European mobility platforms as early as 2010 in its strategic ITS Directive. However, the subsequent, more precise EU legislation (Delegated Regulation 2017/1926) the member states' implementation into national law has been so inconsistent (e.g. the Intelligent Transport Systems Act in Germany) that the EU is currently clearly failing to achieve the goal it set for itself over ten years ago (see Chapter 3.1.1).

One EU state is way ahead of the game, though: Finland. Its "Act on Transport Services," introduced in 2017 and reinforced in 2018, requires all providers of commercial passenger transport services to provide up-to-date data on their schedules, fares, availability, and accessibility in an open, machine-readable format. In addition, mobility service providers must establish an interface through which other service providers, such as platform providers, can obtain at least a standard ticket or access a "reservation" (e.g., when renting an e-scooter). When a ticket is purchased, the buyer's data may only be used for processing the transaction and granting discounts, tickets for longer time periods, or similar transactions. The software or licenses necessary to use the ticket purchasing interface must be made available on fair and reasonable terms (Ministry of Transport and Communications 2018, § III (2) 1-2a). In this context, the law is worded rather vaguely, using phrases such as "open interfaces" or "free, fair, and proportionate" in order to leave room for adjustment in a highly dynamic market (Scientific Services 2020, p. 6). The law is specified by a legal ordinance, which mandates that dynamic information, such as the current location of all scheduled and non-scheduled systems or any delays or restrictions must be transmitted as soon as they are available (FINLEX 2018). The APIs for information and payments are provided through the Finnish NAP.

Box 4: Advantages and disadvantages of the Finnish model and necessary specifications

This approach has several advantages:

- Better insights for the public and political discourse:
  - Researchers can analyze the conditions that make a mobility service successful, which can help legitimize and improve the design of new systems.
- Economic benefits for the mobility services sector:
  - Simplified access to mobility services can significantly increase and even multiply the industry's revenue as the just transport transition progresses.
- Stronger mobility management and enforcement of rules in public spaces:
  - Compliance of mobility service providers can be controlled more easily. For example, it is easy to verify whether e-scooters outside the permitted areas are collected quickly enough.
  - Mobility managers can monitor the impact of mobility trends (e.g., e-bikes), events (e.g., large gatherings), and infrastructure changes (e.g., new mobility stations) on mobility in real time.
  - Obtaining mobility data no longer depends on a multitude of laws at the federal and state levels (e.g. Carsharing-Gesetz CsgG, StrWG NRW) and their implementation in municipalities (e.g. special-use regulations).
- Fair competition and stronger innovation:
  - A *level playing field* is established since all mobility service providers are obligated to share data and are no longer able to circumvent requirements (Lenthe und Bopp 2020).

    - The dominant actors' position of power is weakened as everyone has better access to data and network effects. This reduces barriers to market entry, stimulates competition, and promotes innovation (see Cristescu 2021).
    - Dominant market positions and thus, monopoly/oligopoly returns become less likely.
    - Data from all mobility services becomes available, which allows established and new players to (further) develop their services on a richer data basis (see Denker et al.2017, p. 117).
- Cost savings for the public sector:
    - When municipalities, states, the federal government, transport associations etc. develop and introduce a large number of MaaS platforms congruently, there will be synergies both in terms of effort and the associated personnel and development expenditures.
    - There will be no need to subsidize platforms and their expansion (e.g. by public mobility companies); these funds can instead be used to improve public transport.
- MaaS platforms can be made available nationwide and their deployment no longer depends on local conditions such as:
    - municipalities leveraging their bargaining power due to the high attractiveness of the local market;
    - local authorities' and transport companies' negotiating skills and their willingness to compromise;
    - municipalities' budget situation, which currently has a major impact on public mobility companies' ability to build high-quality platforms;
    - the support and advice provided by transport associations.

The following arguments speak against such legislation:

- The service providers' commercial interests:
    - Competitors gain insight into the profitability of certain areas and the strategies pursued by individual companies. At least for sharing vehicles, this information can be obfuscated by not transmitting vehicle IDs or by changing IDs between start and endpoint.
    - deprives established players of knowledge they could have used to drive the digital transformation.
    - The costs of collecting and processing the data cannot be refinanced directly.
    - impedes marketing efforts, especially special deals via discount systems and season tickets.
- Mobility services might disappear from the market:
    - When individual providers lose previous market advantages, their mobility services may no longer be sufficiently profitable.
- Deliberate choice not to collect any data:
    - Mobility service providers could refrain from collecting data so they are not obligated to make it available to competitors.

- Potential threat to users' data protection:
  - When exact itineraries become visible to third parties, individuals' mobility patterns may be partially disclosed, especially in sparsely populated areas.

There are several aspects to be considered for a similar approach in Germany:

- Prerequisites and support:
  - The technical prerequisites vary greatly between different players. There should be funding programs for building or modifying systems to collect and process vehicle data.
  - The digital infrastructure must be developed in a way that vehicles can transmit their position data nationwide.
  - Implementation should focus on reasonable (but not excessively long) implementation timelines (<5 years); funding could be tiered to decrease annually to encourage timely completion.
  - Providers who fail to provide data and interfaces should be sanctioned with fines, as is the case in Finland.
- Standards and *open-source* components:
  - APIs should be designed as uniformly as possible. A *stakeholder* dialogue should be held with all actors to set standards.
  - It is important to have open-source components available to all stakeholders that can be used easily by as many parties as possible.
- Clarify responsibilities and business models:
  - It should be clarified how platforms are compensated for mediating services, for example, whether and to what extent they can sell tickets with a mark-up.
  - Aspects such as customer service, liability (for example, for damage to vehicles or parking violations), etc. should be clarified.
  - The intermediary platform must verify user eligibility (e.g. driver's license).
- Systematically strengthen the ecological network:
  - It must be carefully considered whether or which mobility services should even be displayed if that same need is served by public transportation.
- Air traffic should not be included:
  - Services in unprofitable areas should be promoted at the municipal level – either through services provided by public transport companies or by subsidizing private providers.
- Protect data protection:
  - From a data protection perspective, vehicle data is unproblematic as long as the vehicle IDs change (see chapter 2.4).

Such an approach would strongly interfere with entrepreneurial self-determination and could call into question the basis of the mobility service providers' business models (see chapter 3.1.3). There may therefore be concern that this approach might oust certain mobility services from the market. However, sharing companies such as Lime, TIER, Dott and Voi as well as ridehailing services Uber and Bolt are still active in Helsinki today. The public sector also remains active, offering both a popular bike sharing system and an on-demand bus.

Since Europe-wide integrated MaaS platforms would be optimal, the German federal government should advocate for the Finnish system as the model for European regulation of intelligent transport systems as consultations get underway to reform the ITS Directive.

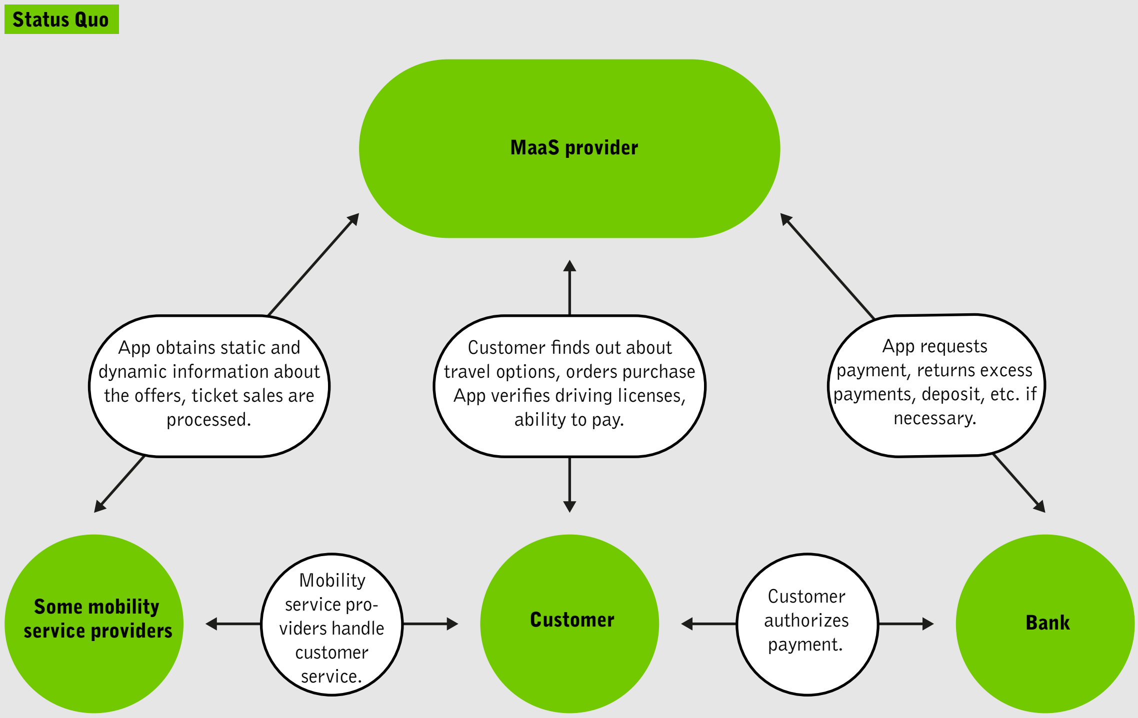
Since this is unlikely to happen in the short term, the aim should be a Germany-wide regulation, for example within the framework of the Mobility Data Act or the Intelligent Transport Systems Act. However, the legislative process will likely be met with major resistance from public and private mobility service providers as well as from municipalities, transport operators, and IT companies that are already operating their own platforms. Such objections may be raised during consultations, e.g. in the current stakeholder dialogues on the Mobility Data Act, as well as in the course of traditional lobbying. The goal must therefore be clearly defined: non-discriminatory brokerage of mobility services by third parties. Consultations should focus on making this goal attainable as easily as possible for all stakeholders. In order to adequately represent the interests of the general public and climate protection, civil society groups, in particular (e.g. VCD, BUND, Deutsche Umwelthilfe), as well as research and think tanks (e.g. Agora Verkehrswende) should be involved.

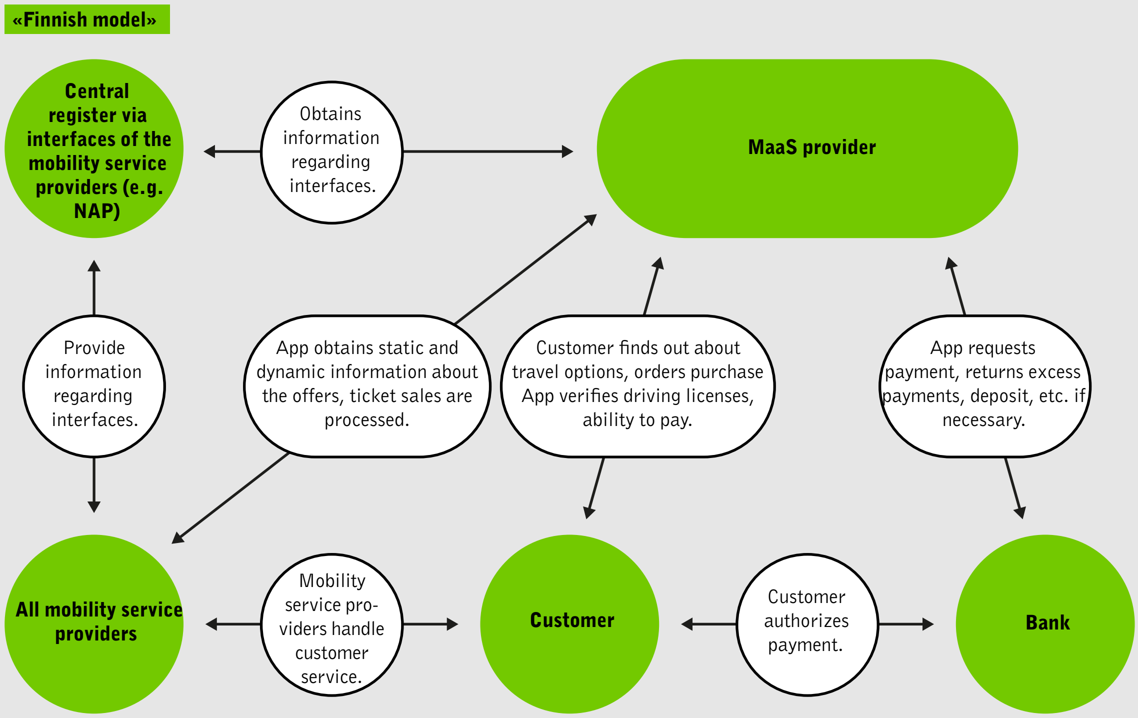
A second-best option would be to build a network of interconnected white-label MaaS platforms with deep integration under public ownership. Implementing a local MaaS platform would be much easier for municipalities or municipal transport companies since they do not need to develop an entirely new platform from scratch and the various mobility service providers can be integrated into the platform across municipalities, both technologically and legally. By linking local systems, passengers could use their local app in all other connected municipalities. The revenue would flow to the respective public transport operator.

In contrast to the "Finnish model," public transport companies would have a clear advantage over global platform companies because they would be marketing their services exclusively. However, the fragmented public transport landscape poses a risk that the platform would not be usable nationwide or would not encompass all services locally. It would also require comprehensive renegotiations between the transport companies and the private service providers for each fare zone.

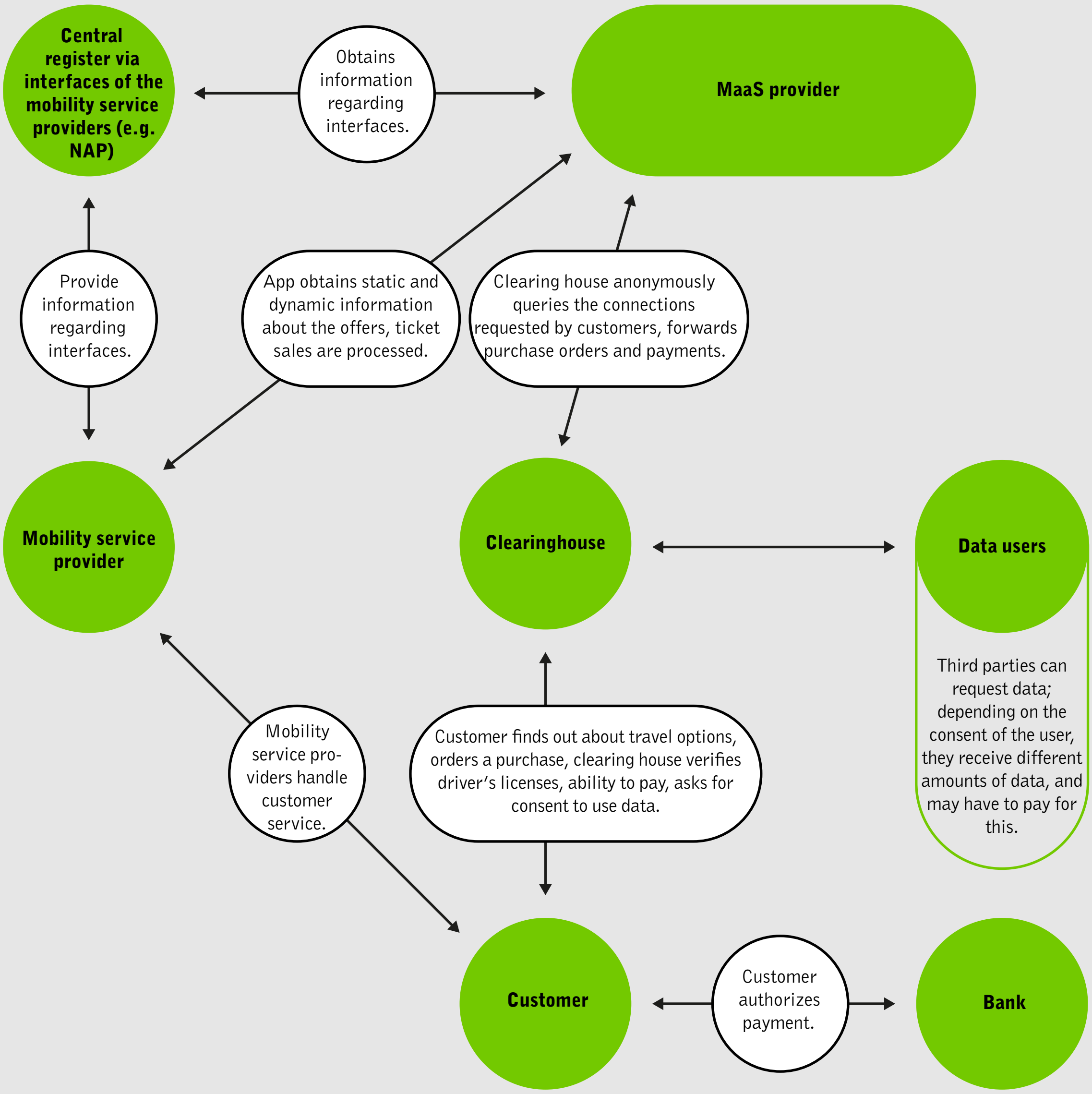
This is the approach driven by "Mobility inside," a company founded in 2019 by the Association of German Transport Companies (VDV) to develop a MaaS solution "from the [public transport] industry for the [public transport] industry." The app, which is funded by the BMDV, now covers the services of 12 transport associations in 9 apps, thus reaching about 40 percent of the population. However, even four years after its launch, neither

Fig. 11: Schematic representation of different MaaS concepts





«Finnish model» + data clearing



long-distance transport nor a single private mobility service has been deep-integrated (Mobility Inside 2023b).

The "Mobility inside" initiative is promising from a public service perspective (mobility for all) as well as from a sustainability perspective, as public transport remains the central player in the mobility services market. But because of the multitude of path dependencies and coordination requirements among public transit agencies, the authors believe that legislation would take effect more quickly and lead to more comprehensive platforms and greater integration cost savings for the sector as a whole.

4.2 Municipal options for traffic control and supply planning

So far, analyzing and controlling mobility behavior at the municipal level has largely been based on traditional survey data (see chapter 3.2). This includes data from household surveys (e.g. SrV or MID) as well as fixed and mobile counting stations that are primarily deployed along main traffic axes. For example, there is continuous data on the flow of automobile traffic and, in some cases, also on bicycle traffic. Spatially aggregated information on the modal split and trip purposes is available at longer intervals. Some municipalities rely on external funding such as survey grants even for such basic monitoring (for SrV, up to 80 percent). This data is primarily used for infrastructure planning; it requires a great effort to capture the effect of measures such as new mobility stations and bicycle lanes or operative mobility management.

Highly detailed spatial and time-based data sets are needed to obtain a robust picture of mobility behavior and to derive systematic and precise mobility management from them. These data sets ought to include start-endpoint relations across municipalities, including the means of transport used, and, ideally, the purpose of the trip. This would make it possible to determine the most suitable mobility services to substitute private transport at specific locations as well as the effects of interventions.

In addition to data on general mobility behavior, data from mobility service providers is also becoming a greater focus of mobility management. However, the data situation is very heterogeneous and mostly insufficient:

- Public transport data (buses, bike sharing, on-demand ridepooling) are usually easy to obtain, but don't include some relevant aspects such as the number of boardings and exits from buses at individual stops. Public transport planning is often done by municipal transport companies who don't even obtain such data in the first place.
- Cab companies are often small and traditional. They have little technical equipment, so data is often unavailable.

- Also, traditional carsharing companies often operate within established structures and are reluctant to share data.
- Newer sharing providers, especially of e-scooters and (e-)bike sharing, are usually willing to share data, not least because municipalities have better leverage using special-use regulations (e.g., § 18 para. 1 sentence 1 StrWG NRW). Municipalities often use pre-built dashboards from the providers for their analysis because they do not have the capacity to process the data on their own.
- Ridehailing providers often try to circumvent regulations by making nominal changes to their business model; data is often not available.

Nationwide procurement of comprehensive mobility data

Since these problems cannot be reliably solved at the municipal level, solutions at the state or federal level should be sought to create greater synergies in keeping with the subsidiarity principle. One option would be to acquire highly detailed mobility datasets at the federal or state level. These can be transferred to the states and municipalities in aggregated, anonymized form without substantial loss of information. The data would need to be calibrated using traditional mobility surveys and data from counting points to adequately represent less digitally inclined users, such as the elderly, children, the impaired, and low-income groups. In order to make the data accessible to all mobility managers, evaluation tools based on open interfaces should be made available in addition to data sets. One example is the software provided by Motiontag, which was enhanced for better data protection compliance in the research project AnoMob by the German Federal Ministry for Education and Research (BMBF). Service companies could be contracted to de-individualize data in bulk, such as the software Aircloak , which was refined in cooperation with a Max Planck Institute.

Obtaining this data for the entire country would require a great financial effort. However, compared to the total sum of local procurement costs, and with a view to urban planning options and climate protection, the bottom line would be positive.

Making data from mobility services available

Regulation as described in chapter 4.1 would, at least, make data on all mobility services available. If this does not seem viable, federal regulations should be pursued. These should empower municipalities to make approval of mobility services contingent upon a data submission requirement. The federal government should define data standards and provide analysis platforms to minimize the required personnel and financial resources and to empower smaller municipalities to benefit from data analysis. Publicly funded solutions for this are already in place, such as the open-source analysis platform of the MIAAS project, which is funded by the BMBF. It enables decision-making and demand planning based on combined data from public transport and shared mobility providers.

For municipalities, there are two other interesting approaches to make mobility data and analysis available at the community level: The POSMO cooperative has taken an in-depth look at the benefits of mobility data for society and is calling on citizens to donate data. Donors can decide for which purposes their data may be used. The DLR Moving Lab automatically collects data from data providers, enriching it with additional information that individuals enter on an app. This creates even more precise and comprehensive data sets. Municipalities could promote such models, for example as part of welcome packages for new citizens; participation could also be remunerated. A second way would be students' university theses. Many young researchers need interesting data sets while both municipalities and mobility service providers need analysts. Synergies can be leveraged when municipalities establish strategic cooperations with university chairs, facilitating academic data use with municipal transport companies and private providers.

5 Conclusion

Transparent, publicly coordinated, and data-secure use of mobility data has the potential to substantially advance the mobility transition. Further advancing MaaS platforms and municipal mobility management is a great and quick-to-implement way to do this. The EU and the Federal Republic of Germany want to see uniform platforms that encourage citizens to switch from cars to mobility services, in conjunction with public transport, walking and cycling, thus reducing the burden on cities and the climate. However, legislation remains hesitant and implementation has been piecemeal.

In Germany, many public transport companies are establishing local mobility platforms based on white-label software solutions or in-house developments. Commercially organized players are also becoming increasingly involved in the market. ShareNow has established itself as a provider that integrates e-bikes, e-scooters, e-scooters, carsharing, cabs, and ridehailing from various providers. The Verkehrsverbund Rhein-Ruhr (VRR) is the first transport association to join this effort and is creating a very attractive, supra-regional platform.

In the absence of government intervention, the strong network effects in the platform business will likely produce a monopolistic or oligopolistic market structure. In this scenario, one or a few platforms would divide the market among themselves and develop market power over both mobility service providers and customers. In the worst-case scenario for environmental protection, data protection, and inclusive mobility, private platforms would boost the convenient use of car-based mobility services by making them the focus of additional services and pushing back public transportation.

The challenge for policymakers is to drive the mobility transition while ensuring innovation and competition, all without leaving smaller communities with fewer resources behind. The most effective and fair solution would be to legally require all mobility service providers to make their static and dynamic vehicle data and a payment interface available through the NAP. At a minimum, access should be available to all other mobility service providers as well as government agencies and researchers. The Finnish legislation could serve as guidance for this; their experiences should be surveyed and included. Just a few years ago, there was still much confusion about technical standards and system architectures. Today's state of development offers an opportunity to define uniform, open standards in a stakeholder dialog. Germany-wide platforms could integrate all sustainable mobility offerings without a need for extensive renegotiations on technical standards, revenue sharing, or joint marketing. This could also prevent the consolidation of path dependencies that would put individual players in key positions with significant market power.

Each MaaS platform that obtains data from a certain mobility service via the NAP should be required to display all posted offerings of a given mobility mode. Customers should be able to narrow down the displayed results based on certain criteria. This fundamental prohibition of discrimination would allow new companies to directly address a large potential customer base. At the same time, a far better understanding of overall demand for mobility, shared by all providers, could drive innovation and optimize offerings. Since users would have easy access to all sharing fleets, the number of sharing vehicles could decrease while their profitability and benefit for the population increases. Along with appropriate incentive systems, a spatial redistribution of sharing vehicles could also help expand them into more remote areas.

With many established mobility service providers mired in technological and organizational path dependencies, it is to be expected that various parties will resist such regulation. This is why stakeholder dialogs and the legislative process should pay attention to those actors who are familiar with practical problems, but are not interwined in a tight mesh of interests.

If a general obligation to integrate all offerings turns out to be impracticable, a second-best solution could win the day: a platform system driven by public actors that could be replicated with little effort, connecting the MaaS platforms of the greatest possible number of public transit companies, such as the one currently being developed by the VDV. This Germany-wide platform unlocks great synergies for the cities and regions that adopt it: The technical integration of services and their conditions have to be clarified only once with the various mobility providers. The cost for (further) developing the platforms can also be significantly reduced. However, since this avenue relies on private providers' willingness to cooperate, there is also a risk that a private platform will prevail instead of a public platform, with convenient and easy-to-use automotive offers that end up drawing customers away from buses and railways.

A legal obligation for mobility service providers to disclose vehicle data would also advance municipal mobility management. Today, the availability of data from mobility providers varies widely. But even if providers do submit the data, a municipality's ability to analyze this incomplete picture depends on its capacity to develop or procure appropriate analytical tools. Great amounts of human and financial resources are invested in developing similar tools in different places and at different levels. In the meantime, data standards have been established for various means of transport (esp. MDS, siri, GBFS, GTFS, NeTex). It would therefore make sense to make standardized, easy-to-use software solutions available nationwide. This way, all municipalities and transport associations could analyze mobility data with little effort, even without specially trained personnel. This data and such analyses would allow for better monitoring and a more strategic design of mobility services.

The very high prevalence of smartphones today is an opportunity to gain a more comprehensive understanding of the trajectories traveled. The use of mobility services and infrastructures, such as bike paths, can be recorded over time and across an entire area, offering the opportunity to better adapt these services to actual demand. Data quality, representativeness, and data protection are key here. Dependence on large private companies should be avoided.

Leveraging mobility data is just as relevant for mobility management in small municipalities as it is for entire districts or large cities. Moreover, due to interconnected commuting patterns and the environmental relevance of long-distance travel, supraregional data sets are key to obtaining a comprehensive overview of mobility behavior. Since data sets from mobile phone providers or from apps are also supraregional in nature, and it is much cheaper to procure such data jointly than for each municipality to buy their own, this issue should also be addressed at the federal level. Centralized procurement can also be coupled with a data analytics software solution that is accessible to all parties, allowing easy access without the need for extensive data expertise. This way, innovations could quickly take effect nationwide.

Both better insights into mobility patterns and services used can help better serve the specific mobility needs of different groups, such as people with care work responsibilities or special needs. This is why factors such as accessibility should be considered when determining data transfer obligations or procuring data sets.

Since mobility services increase the flexibility and availability of these forms of mobility, they can particularly benefit women and their more complex itineraries. Offering cargo options should also be considered because they make a transport mode significantly more useful for caregivers.

Digitization unlocks a potential for fundamentally novel mobility services and analyses. Currently, local progress depends on the financial strength of the municipalities, the commitment of municipal employees, and the support of transport associations and state institutions (such as the Future Network Mobility NRW). This has resulted in an uneven development, high costs due to redundant developments, and high personnel expenses, all of which is unnecessary given the very low marginal cost of scaling digital systems. In many areas, we should aim for nationwide solutions which could make the possibilities of digitization more efficient as well as more effective.

With a publicly regulated, integrated mobility platform and standardized, easy-to-evaluate mobility data for transportation planning, mobility offerings in urban and rural areas can become better and more user-friendly. With its integrating effect across Germany, transcending the boundaries of municipalities, transport associations, and federal states, the nationwide Deutschlandticket can serve as a blueprint and a starting point for making sustainable mobility more attractive. By accelerating the expansion of public transport, setting service standards for better local transport, and imposing comprehensive minimum requirements for sharing services, we can create an attractive transport system that will encourage more and more people in cities and in rural areas to switch from private cars to eco-friendly means of transportation.

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Glossary

Check-in/check-out system: Using these applications, public transport passengers can check in at their stop of departure and check out at their destination. They don't have to worry about fare zones and can buy tickets even faster.

Dashboard: This term refers to websites on which users can view tables or graphics containing data on a given subject matter. Many dashboards are updated daily.

Non-discriminatory display/platform: A platform that displays all offers of one type (e.g. all bikesharing systems) without highlighting any particular provider.

Emissions: The term refers to emitting substances or signals. In this report, CO_2 emissions are of particular importance because they amplify the greenhouse effect. In the lingo of the mobility sector, however, the term also includes other forms of emissions such as noise or odor.

Free-floating, station-based: Free-floating vehicles can be parked in any available parking space within a defined area, while station-based vehicles must be returned to the providers' designated locations. Station-based carsharing vehicles often need to be booked in advance. Sharing stations are sometimes labelled by signs or markings on the ground, yet they can also be labelled virtually, i.e. only be displayed in the app.

Heatmap: A visual representation of the density of use of a service at a certain location within a given period of time. This form of representation is compatible with data protection since the start and endpoints of individual trips are made undetectable by way of temporal and/or spatial aggregation. However, it does provide insights into mobility patterns, visualizing the intensity of use in a given area or on a certain street.

Intermodality/multimodality: Intermodality refers to the use of multiple modes of transportation within a given trip. Multimodality, on the other hand, refers to the use of multiple modes of transportation by one person on different routes.

Level playing field: This term refers to equal competitive opportunities for all market participants.

Non-scheduled (or on-demand) transport, scheduled transport: Scheduled transport services operate along a fixed route at fixed times. Non-scheduled or on-demand services only run when there is demand. It can follow fixed routes (for example, on-demand shared cabs) or serve an area or specific stops without a fixed route (for example, on-demand ride pooling).

Micromobility: Micromobility includes small and light vehicles that are powered by muscle power or electricity and mostly used to transport one individual at a time. These include (e-)scooters, (e-)pedal scooters, e-scooters, segways, light e-vehicles, hoverboards, mono-wheels, and (e-)skateboards. A detailed overview can be found here.

MIT: "Motorized private transport" (MPT) includes all journeys by car, motorcycle, RV, etc. driven by end users themselves.

Mobility versus traffic: Mobility is the possibility of getting from point A to point B. Traffic, on the other hand, measures the volume of actual movements. High traffic volumes thus do not necessarily equal high levels of mobility (for example, in rural areas). Mobility can increase when traffic decreases, for example, because of a new neighborhood supermarket or telework.

Mobility poverty: Mobility poverty refers to disadvantaged groups' reduced ability to reach the places they want to go. It is due to a combination of individual restrictions (for example, financial hardship) and the general conditions (for example, poorly developed public transport). Children, the elderly, the poor, and the impaired are therefore the primary groups affected by mobility poverty.

Mobility services: These are services that transport people for a fee. In other words, they enable mobility without owning a vehicle. They are usually offered in locations where many people live or work.

Mobility mode/mobility mode/modes: These terms refer to a group of transportation modes with similar characteristics. In passenger transport, we traditionally distinguish the following modes: Pedestrian traffic, bicycle traffic, motorized private transport, and public transport.

Mobility as a Service: MaaS means that instead of vehicles, users buy and sell trips. To this end, various mobility services such as car and bike sharing, public transport, and cabs are bundled into a single platform. Customers can obtain information about the available options on the platforms and in some cases also book and pay for the means of transport of their choice directly.

Mobile point, mobile station: These are hubs of interchange that connect different modes of mobility and thus facilitate intermodality. While there is no established uniform designation, the term "mobile station" often designates transfer options at public transport hubs, while "mobile point" often means stops in residential areas that offer micro-mobility and bicycle parking, for example.

Public transport companies, transport associations: Public or municipal transport companies are the central players in bus transport in Germany. They are usually wholly owned by municipalities or other public entities. Their purpose is to provide mobility for all segments of the population. They are usually either subsidized by municipalities or funded by surpluses from other lines of business (such as municipal utilities). They often form alliances with each other and/or the public railway systems in order to coordinate their services and streamline ticket sales.

On-demand ride pooling: This transportation service is based on a fleet of shared cabs that call at a variety of stops. When users request a ride, a background system calculates which of the cabs in the system can make the best route and dispatches it for the requested trip. Currently, there are model projects to establish this service, which would reduce dependence on automobiles in rural areas. These systems are integrated into the public transport system and are heavily subsidized. Commercial providers exist in metropolitan areas.

ÖPNV/ÖV: Local public transport (in German: Öffentlicher Personennahverkehr, short: ÖPNV) is the system of local and regional bus and train services that operate on behalf of and generally with financial support from the public sector. Together with long-distance transport, it forms the public transport system (ÖV).

Peer-to-peer-Sharing: refers to end users sharing their vehicles. In the context of MaaS platforms, the relevant forms of peer-to-peer sharing are the ones that transact via digital platforms. An example of this is the website PaulCamper.

POI: Points of interest are destinations such as hospitals, attractions, restaurants, etc. They are relevant for MaaS applications because they allow route calculation without having to enter an address.

Ride hailing: Refers to app-based, cab-like services that transport customers within a defined area. Unlike cabs, they are free to set their own fares and are not obligated to carry any and all passengers. They are, however, subject to special conditions: For example, they are not allowed to pick up passengers on the side of the road and they usually have to return to their place of business after completing a trip.

Deep integration: MaaS platforms distinguish between different levels of integration: 0 – no integration. 1 – information: The routing includes other means of transport, sometimes also displaying prices or fares; the booking is made via the provider's platform. 2 – booking: Individual trips offered by several different providers can be booked and paid via one platform. 3 – joint distribution: Subscriptions or budgets across several providers are possible. 4 – integration of social goals: Incentives and similar offers that serve environmental or social goals, offered, for example, in close cooperation with municipalities. In this publication, the term "deep integration" refers to integration levels 3 and above.

Trajectory: The exact path from the starting point to the destination.

Supply economics/supply work: Includes unpaid care for third parties, such as children or neighbors. In terms of work volume, it is the largest part of the economy.

White-label platforms/products: A white-label platform is an application-ready MaaS software that is designed separately for different customers and linked to their other IT systems so as to require little additional development work.

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