Distr.: General
15 February 2019

English only

Economic Commission for Europe

Inland Transport Committee

Eighty-first session
Geneva, 19-22 February 2019
Item 4 (c) of the provisional agenda
Strategic questions of a horizontal policy nature
Analytical work on transport

Transport Trends and Economics 2018–2019: Mobility as a Service

Note by the secretariat

Background

This document contains a draft advance text of a paper on Mobility as a Service, that is being developed under the leadership of the Working Part on Transport Trends and Economics.

Chapter 1
Mobility as a Service: concept, objectives and architecture (Prof. Dimitris Dimitriou)

1.1 Introduction

In recent years, the planning and delivery of community transportation have seen their own "industrial revolution," except at a much quicker pace than was ever seen in the 19th century version. The field has experienced the advent of sophisticated algorithms for scheduling routes and trips, GIS-based tracking and monitoring of vehicles, apps that allow customers to more directly interface with services and receive minute by minute service updates, and now even automated operations of vehicles. Simultaneously, and largely enabled by these technological advances, the range of modes for moving about the community has rapidly evolved. To the traditional choices of travel by private automobile, bus, taxi, and train, we have now added bikeshare, carshare, on-demand carpooling and shuttling, vanpooling, and transportation network companies.

Most of these advances have been added to the community transportation menu piecemeal, leaving transportation planners and operators to figure out how to integrate them into existing options. The focus of this brief is on one promising strategy for giving customers a single interface through which they can access any and all transportation services in their community: Mobility as a Service (MaaS).

1.2. The MaaS concept

The MaaS model covers several concepts that have been extensively discussed in the transportation sector during last decade. These are the integration, interconnectivity and optimization of the transport services, smart and seamless mobility, and sustainability. MaaS model also includes applications that have recently emerged via the Internet of Things (IoT) and the sharing economy, such as the term "as a service" mainly related to service personalization, optimization and sustainability.

Adoption of MaaS is growing as the IoT is continuing adopted across industries new applications, in governments' priorities, and in consumers' daily lives. Looking carefully, its increasingly observing how data generated by connected devices is helping businesses run more efficiently, gain insight into business processes, and make real-time decisions. For consumers, access to data is changing how they are informed about the status of vehicles and family members as well as their own mobility attitudes in terms of health and fitness. In connectivity and mobility, IoT is just beginning a new revolution, where shift from digitally enabling the physical to automating and augmenting the human experience with a connected world. Transport is one of the industries that are forecast to spend the most on IoT solutions in 2019, driving a direct output towards transportation investments of about $70 billion and more than double spill over budget effects (including manufacturing, consumption and utilities). In transportation, more than half of IoT spending will go toward freight monitoring, followed by fleet management in urban distribution networks or systems.

Although, there are already mobility services that cover these terms (i.e. car-sharing, on-demand transport), they usually operate in silo and are not integrated with other modes - especially with traditional public transport services that usually include services offered by urban bus and rail/metro/tram networks. MaaS envisages enabling a co-operative and interconnected single transport market and providing users with hassle free mobility. In order for this to be achieved a new player has to enter the transport market, namely the MaaS provider. The MaaS provider should be able to remove many of the pain points that are related to travelling and offer users an advanced travel experience. Building on these, MaaS is defined as follows:

Mobility as a Service (MaaS) is a user-centric management approach, using intelligent mobility distribution options and Internet of Thinks applications, in which all mobility service providers' offerings a mobility service is aggregated by a sole mobility provider, the MaaS provider, and supplied to users through a single digital platform, providing real time information and on-line payment options.

Currently, the user must use numerous tools in order to find information and purchase access to different transport modes, even different services in the same transport mode. Travellers' usually use different journey planning tools to implement their trips. However, most of the existing journey planners do not offer information for intermodal trips or alternative route options (that is, do not combine more than one transport mode – with the exception of walking that is usually the access and egress mobility option), and only include some of the available transport modes in an area.

Furthermore, the user has to use different payment methods for each transport mode or service even for the same route; for example, some transport operators only accept cash, other accept credit cards, operator' prepaid smartcards, smartphone payment or PayPal. This means that the user, usually, needs different tickets/ways to access each transport mode. Its noteworthy, recently, in many cities around the world, public transports are accessed using the same ticket/card, but there is no ticket integration with other transport modes, e.g. interurban train or regional bus services. These are only some of the inefficiency areas of transport services operation that effected essential mode choice and mobility. There is too many researches highlight that the dull-time or the waist time at stations or platforms are one of the most mis-attractive factor for mass transports, especially, if the trip include interchanges between different services or modes.

Therefore, MaaS adopting the concept of IoT and by utilizing personal preferences promotes the choice of sustainable travel behaviours focus to improve intermodality (use of two or more transport modes in a trip) and multimodality (use of different modes for different trips). The MaaS concept removes many of these user-related mobility inefficient issues, promoting efficiency by giving in advance trip performance outputs at least in terms of physical metrics (time, distance, etc.) and cost profile (payment option, special offers, etc), but also in terms of many other personal interest combinations e.g. health issues, comfortability, accuracy, safety, etc.

The MaaS provider is an intermediate between transport operators and users. It could be referred as a digital personal mobility agent. The MaaS provider uses the data that each transport operator offers (via secure APIs), buys capacity from the transport operators and resells it to users. The users only use one interface to find information and choose the preferred transport mode for their trips. The MaaS operator can propose the ideal combination of transport modes to them for each trip by knowing the network conditions in real time (supply side) and the preferences of users (demand side). In other words, the MaaS provider can optimize the supply and the demand. To explain through a comparison, the MaaS provider could act as Expedia does in the tourism sector or as Amazon in the retail sector; instead of visiting and searching the websites of each hotel, airline or car rental company, customers can find all the information they need on one website, and they can purchase one service or combinations of services in a one-stop-shop manner.

MaaS envisages not only bridging the gap across transport operators in the same city, but also across different cities and initiates the idea of roaming in the transport sector. Nowadays, it is common for someone to live in one city (usually due to better quality of life or properties prices) and commute to another. At the same time long-distance business trips have been increased. The MaaS providers could cover the travel needs of their customers not only in their home-city, but anywhere around the world where they operate. This is already a feature that some of the on demand and car-sharing services offer. For example, you can use/access Uber in all the cities where the company operates by using the same app and by having exactly the same user account and payment details. Figure 1 depicts the current situation for urban and intercity trips from a user's point of view and the way transport services could be accessed when a MaaS service is available.

1.3 MaaS Objectives and Definitions

1.3.1 Key objective

In one word, MaaS is a new digital oriented mobility management tool, combining personal needs and offered mobility options. According to the MaaS Alliance, "Mobility as a Service (MaaS) puts users, both travellers and goods, at the core of transport services, offering them tailor-made mobility solutions based on their individual needs. This means that, for the first time, easy access to the most appropriate transport mode or service will be included in a bundle of flexible travel service options for end users.

The following figure illustrates the MaaS ecosystem.

Figure 1: MaaS ecosystem

[placeholder for the figure]

There are four objectives of MaaS, as follows:

• Seamless and efficient flow of information, goods, and people both locally and through long distances;

• Globally scalable door-to-door mobility services without owning a car;

• A better level of service than the private car; and

• An open ecosystem for information and services in intelligent transportation.

There are several similarities between MaaS, and one call-one click services and mobility management in general. There are differences as well. In terms of the similarities, one overall vision of all three concepts is to improve liveability in a community or region. More specifically, one call-one click can be a component of mobility management, given that mobility management is “a process of managing a coordinated community-wide transportation service.

Regarding, Mobility as a Service network, key characteristic is that comprised of the operations and infrastructures of multiple trip providers in partnership with each other. The key planning elements of the mobility management should:

• Emphasizes the discrete travel needs of individual consumers;

• Emphasizes the entire trip, not just that portion of the trip on one mode or another

• Offers a full range of travel options to the single occupant of an automobile

• Cultivates partnerships and multi-agency activities

• Offers a single point of access for customers to multiple travel modes

• Applies advanced technologies

• Improves the information that is available about those services

In terms of the differences, the one major difference is that in MaaS, the consumer purchases a “package” of transportation services, typically on a monthly basis. Further, MaaS is operated by one entity, which can be a public or private organization. While mobility management can be performed by one organization, it is not necessarily responsible for negotiating financial relationships with transportation service providers. Finally, mobility management’s objectives are typically more focused on the traveller with special needs, while MaaS’s objectives focus is on providing individual mobility with a better level of service than that of a single-occupant vehicle.

1.3.2 Key definitions

MaaS is essentially the next step in the progression from isolated agency-by-agency information and operations to a one-call/one-click/one-pay transportation network. The philosophy behind MaaS is to direct people to their most appropriate mobility options, in real time, through a single, unified trip planning and payment application.

This term is frequently confused and misused, and it is important to understand what it means. ERTICO, Europe’s Intelligent Transportation Systems partnership, describes MaaS as “putting users, both travelers and goods, at the core of transport services, offering them tailor-made mobility solutions based on their individual needs. This means that, for the first time, easy access to the most appropriate transport mode or service will be included in a bundle of flexible travel service options for end users."

For a visual understanding of MaaS, this video provides a great demonstration. In communities with an array of transportation options, such as large urban areas, embracing the MaaS model provides maximum flexibility to customers for deciding among travel modes, schedules, and price points. In doing so, travelers become better consumers, learning about all alternatives to driving alone and more precisely identifying the mode that suits them best for a particular trip, without their having to commit to that mode for other trips. Having this type of centralized information and choice can also greatly improve access for travelers with mobility challenges, allowing them to understand the array of choices before them and decide on the most appropriate.

Benefits accrue at the system level from MaaS as well: demand is more efficiently spread across modes, communities are better able to identify gaps where travel choices are still sparse, and partnerships to fill gaps are encouraged. To be more proactive, providers can even actively determine areas of unmet demand by tracking searches for origins and destinations and comparing to service availability.

This can be particularly helpful in small urban and rural communities, which lack the varied menu of options seen in urban areas that are so crucial to a person's access to work or health care. MaaS would allow mobility managers in social service and public agencies to identify service gaps and opportunities to incorporate new providers into the network.

1.4 A depiction of Mobility as a Service architecture

Early versions of MaaS already exist, and some transportation entities are building their foundations with eyes toward being ready for full integration with public policy. It remains to be seen how its more advanced levels will take shape, but it is clear that there are many iterations communities would have to go through in order to reach those later stages. To fully understand the path to MaaS, it helps to view this progression as a set of steps through multiple stages or "levels." These defined levels not only provide benchmarks from which communities can evaluate their investments and resulting changes, but also provide a vision for what they want to accomplish.

Jana Sochor, of Chalmers University of Tech & RISE in Sweden, presented a Topology of MaaS to the ITS 2017 World Congress which serves as a useful guide to understand where a community stands along the spectrum of Mobility as a Service.

1 Image Credit: Carol Schweiger's presentation to ITS World Congress 2017

The central element of Mobility-as-a-Service requires a mobility platform that offers mobility services across modes. Similar platforms had already been developed in the past and several examples were presented and discussed at the Forum (see box). A controversial question that emerged was who should set up such platforms. The experiences presented showed that manufacturers as well as transport operators that are active players in the transport market have the capability of developing such platforms while allowing the necessary openness to other providers to be integrated in them. Yet to achieve a fully transparent and equal system an independent body would have to be in charge of this task in the future. This however seems complicated and it remains questionable how it could be managed and financed. Overall it became clear that operators, manufacturers as well as many newcomers currently have a keen interest in mobility platforms. Comparisons were made to booking platforms in other sectors. A mobility platform could be considered

To help in understanding what these steps look like, here are some real-world examples of Levels One through Four:

Level One:

Level One represents the loose integration of information into one interface. There are two forms this can take: one-call/one-click centers or informational apps. There are several examples of one-call/one-click sites to explore, many of which were developed under the Federal Transit Administration's Veterans Transportation and Community Living Initiative grants (2010-2012).

Find My Ride PA, a Pennsylvania-based service, provides a good example of helping anyone identify and evaluate options to meet their transportation needs. In some cases, users can even book a trip directly. Currently, FindMyRidePA is available in seven counties (Adams, Cambria, Cumberland, Dauphin, Franklin, Lebanon and York) and will be available in additional counties in the near future. At this time, the transportation services available through FindMyRidePA are limited to local public transportation options (i.e., fixed-route buses that operate on fixed schedules and shared-ride services) but will be expanded over time to include commercial services (e.g. taxi, train, private bus carriers etc.) and other non-profit transportation services.

There are also a growing number of digital travel information aggregators to choose from:

• Transit App collects all possible modes of travel (excluding solo driving) into a useful menu which allows customers to visualize what is available near any given location and how each option gets them to their destinations. In cities like Washington, D.C., the app has even integrated locations of local dockless bikeshare bikes. Its routing software also helps users understand the total trip length of any mode, including the walk to the transit stop or bikeshare bike, and helps travelers download and open the required apps to complete their journey.

• Citymapper focuses on multimodality, meaning trips that use more than one type of transportation, such as mixing the bus and the train, to reach a destination. The app includes route planning that "creates new trip possibilities that [people] never knew existed" to educate users about how they can make their trips more efficient as well as more cost-effective. To help in larger transit systems, Citymapper even provides step-by-step instructions on how to navigate stations, including the best spot to board a train. It even guesses how long a trip might take in the future on catapults or personal jetpacks!

• TransitScreen, a Washington, D.C., based company, takes a slightly different approach by focusing directly on behavior change. By placing real time transit information in front of people at key locations, the company hopes to influence travelers' transit decisions. The screens offer real-time information that highlight nearby options and arrival times, thus increasing awareness of existing transit options beyond driving.

Level Two:

Level Two builds upon the information aggregators by allowing customers to book and pay for their trip without having to navigate away from the planner. Importantly, travelers would be able to pay for trips that use services from multiple operators with just one ticket or pass.

Germany's moovel and Finland's Whim have introduced multimodal ticketing in multiple cities, and continue to grow their offerings across the continent. For example, moovel's customers can now book and pay for a train ride on Deutsche Bahn, Germany's national train service, and then cover the last stretch of their trip with Car2Go or NextBike bikeshare.

What makes this MaaS Level such an important development is the impact of this seamless "plan-decide-pay" option on human behavior. Let's take driving as an example. Part of what typically pushes travelers who live where there are multiple transportation options available to nonetheless drive themselves in their own cars is the ease with which they can just hop into the car, whenever they want, and go. In this scenario, there are basically two decision points: one, I will drive, and two, I get in the car. What humans are somehow able to forget along this decision path until it is too late is the aggravation of keeping the car fueled, maintained and ready to go; sitting in traffic; and searching for some place to park that car at their destination.

So, to entice people out of their cars, other transportation modes need to mimic the perceived ease of deciding and then driving a privately owned vehicle, to the extent possible. To be an equally or almost equally attractive choice, multi-modal transportation systems need to decrease the “friction” for individuals as they move from considering to doing, friction caused by having to take multiple actions or make multiple decisions. Integrating planning and payment into one space is a giant step toward achieving this.

In rural areas it is much more common for people to not have another transportation choice that comes even remotely close to the efficiency and convenience of driving their car. The challenge for rural mobility managers is also different; rather than focusing on moving people from their cars to other transportation modes, they are rather engaged in figuring out how to provide rides for those who don't have access to a vehicle or need an alternative in the case of an emergency. Success for rural mobility managers is to give people access to essential destinations.

Level Three:

Level Three MaaS builds on the one-stop model of Level Two integration, adding a layer of service through bundling. In Level Three, customers can still choose to pay per single trip, just as in Level Two, but now also have the option to purchase a subscription to different packages of services, offered at different price points depending on what is included in the package. This allows users to choose which modes they envision they will most likely use and pay the membership fee that covers a certain amount of travel within those modes.

Whim’s app in Helsinki includes two subscription levels which show the range of what can be offered: €49 per month buys unlimited transit use, and discounted taxi rides, car rentals, and bikeshare trips within the city, whereas €499 per month allows unlimited use on all modes. (Note that Whim compares the cost of this unlimited package to the cost of owning a car, but with far more options than traditional ownership provides).

2 Image Credit: Screenshot London Department for Transport video on MaaS

Both subscription packages also offer options for traveling into the greater Helsinki region for a surcharge, showing how the model is viable beyond just dense urban cores.

In Gothenburg, Sweden, a company named UbiGo conducted a study on the viability of a Level Three model, and found that users adopted MaaS quickly and easily. The pilot’s subjects were even disappointed in it ending, and now the company hopes to launch a full service in Stockholm.

The up-front payment model offered through UbiGo and Whim type systems, versus a pay-as-you-go model, makes it even easier for people to make positive decisions to use alternatives to private vehicles since all one has to do is “unlock” their trip with a ticket or app. In this way, people are incentivized to use the modes that they’ve already “bought.”

In addition, the true cost of moving around is made more apparent to consumers, and helps them to compare the value of what they have purchased with other options, such as car ownership.

Whim and UbiGo are out in front on exploring these later levels of Mobility as a Service. So far their experiences provide the best view of what this approach can look like, and especially in the case of UbiGo, how people may use MaaS.

Level Four:

Level Four of Mobility as a Service (MaaS) represents the fulfillment of this concept as the industry currently views it. This involves integrating the technologies and payment systems into general public policy and governance structures.

While the earlier MaaS levels involve operators acting somewhat autonomously alongside their partners, Level Four requires the full participation of the local governing structure to integrate MaaS as a core component of the transportation network.

This stage of MaaS remains theoretical for the most part, with few if any active examples. That said, California hopes to take the lead in the coming years; their pending experiments will inform how governments can work with communities to reach full MaaS implementation.

At January's TransportationCamp DC 2018 in Arlington, Virginia, Jim Baker of the California Integrated Travel Program introduced a program in which California's Department of Transportation (CalTrans) aims to integrate travel planning and fare payment across as many modes and providers as possible in the state.

When the program fully forms, travelers should be able to figure out their travel from one end of the state to the other using one interface and making one payment.

Baker explained to the audience that the program wouldn't replace current electronic payment systems, such as their smart cards, but would instead act as an umbrella option that would give users access to all California providers. Thus, a resident of Los Angeles with a TAP card would be able to use it in San Francisco or Red Bluff and vice versa. In addition, the state plans to procure and install the necessary technology for smaller systems who currently do not operate on electronic payment to be integrated into this umbrella system.

This effort is still conceptual, with Baker and his team reaching out to transit providers across the state for feedback on what would enable or prevent the program's success. As a result, the state is well aware that this is an experiment, but the ambitious nature of it fits in with a more comprehensive vision of managing mobility as technologies like autonomous vehicles emerge, and positioning systems early on to serve communities equitably.

1.5 The roles of different transport modes and services in MaaS

The current role of different transport modes is expected to change to fit to service-oriented transport system of the future. This section describes MaaS-related changes in different transport modes and services. The section is divided three parts: cars, public transport and cycling. The section "Cars" discusses motor vehicles such privately own cars, car-sharing, car rental, and taxis.

1.5.1 The role of cars in MaaS

One of the key issues in MaaS is the role of a car. The fundament of new mobility services is the possibility to seamless and reliable mobility without owning a car (Ambrosino et al., 2016). Changes in car ownerships would probably mean more popular times for car-sharing. Car-sharing offers similar options as private cars but without ownership encouraging to try alternative modes, and when car-sharing is one of the alternatives instead of a private car, the actual cost of the trip is easy to compare to other modes (Huwer, 2004). Consequently, the different transport modes are at the same starting point when owning a car does not distort the choice of transport mode. Successful car-sharing service requires the crowd and is thus the most suitable in high-density urban structure (Giesecke et al., 2016). If there is often heavy goods or many children to carry, owning a car may be a suitable choice, which needs to be considered when service providers and authorities develop new services (Mattioli et al., 2016).

Free-floating car-sharing is a modern model compared to station based car-sharing as freefloating service enables to pick up a car anywhere within operation area as long as the car is free, and to drop off the car within the same area (Becker et al., 2017a). The traditional station based service, in which the beforehand determined starting point and end point for a trip restrict the service, is assessed to affect more towards using sustainable transport modes than free-floating car-sharing (Becker et al., 2017a). Car-sharing in its alternative ways is anyway an important factor in the service concept, but as a separate service it does not provide revolutionary changes (Giesecke et al., 2016).

It is still unclear, who is going to own the cars in the future but someone has to be the owner (Hensher, 2017). Nowadays the majority of the cars are owned by households. Consequently, it seems unlikely or it at least takes several years before owning transfers widely to other actors e.g. car-sharing companies. Car-sharing companies of today may not be capable of owning very large numbers of vehicles, which could be the reason why private persons release their cars to joint use but still own the cars (Hensher, 2017). The quickly developing self-driving cars could change mobility considerably if they are utilized as a service. Pakush et al. (2016) estimated that some of the self-driving cars will be privately owned and rest of them used as a service, and this combination would reduce the amount of cars on roads. Present-day taxi services (e.g. Uber and Lyft) are already part of the transport system's services but their business model may have too little upgrades compared to regular taxis for being a successful member of MaaS (Giesecke et al., 2016).

Decreasing car traffic causes positive impacts to climate and urban space and hence car ownership is an important question (Huwer, 2004). In itself, car-sharing is not more environmentally friendly than any other way of car usage as it also causes congestion but car-sharing companies typically offer newer and smaller cars than taxi services e.g. Uber (Giesecke et al., 2016). However, when cars are not privately owned, there is, supposedly, a bit higher threshold to travel by car than by other transport modes. In service-oriented transport system, driving a car, which can be in the form of car-sharing, can be managed better at the strategic level, which may reduce car traffic (Huwer, 2004).

1.5.2 The role of public transport in MaaS

The increasing use of private cars has created difficulties to conventional public transport during the recent decades (Ambrosino et al., 2016). At the same time, digitalization has made the use of buses and trains easier as electronic payment, web based route planning and real-time information has been introduced (Melis et al., 2016). However, conventional public transport needs to adapt in the new MaaS model as the current model is not that flexible to offer customer specified mobility, which is the basis of the MaaS model (Hensher, 2017). Reliable car-sharing and on-demand services may decrease the number of passengers in public transport but MaaS can also provide new ways to develop public transport. Fixed-route bus services with high service level are not cost-effective in rural areas, which leads to a lower service level and further lack of passengers (Atasoy et al., 2015). On-demand based MaaS scheme could be capable of providing sustainable transport also to low-density areas.

Typical model with geographic boundaries in producing public transport restricts the flexibility of public transport to act more as point-to-point service (Hensher, 2017). By using smart technology, flexible point-to-point services can be offered by demand-based systems together with conventional services with timetabled routes (Hensher, 2017). As an advantage in flexible public transport, trip's point of origin can act as waiting place and hence there is no need to wait on a bus stop. This may lead to an observation that flexible public transport seems to be more attractive also from car driver's point of view than conventional public transport. (Frei et al., 2017) Adaptation of public transport to the model that fits in MaaS requires more experiences e.g. on how a service-oriented transport system affects people's mobility. Travelling by a privately owned car could be reduced as new services can exploit real-time data on demand, thus produce enhanced service level of public transport and promote connectivity with other modes (Hensher, 2017).

How efficiently public transport can be integrated to other modes, is a crucial question for the future role of public transport. Hensher (2017) presented two scenarios including a combination of bus services and Uber-type point-to-point services, which is a possible scenario for the future as well as the combination of bus services and ride-sharing. Point-topoint services would consist of integration of conventional taxis and public transport. Ridesharing would instead mean point-via-point-to-point services, which is more like conventional public transport than car traffic but the cost is lower. In ride-sharing, a small bus could replace a car if the amount of passengers is appropriate, but at the same time a fleet of small and large buses would add maintenance cost. It is however unclear, how these kind of solutions would affect the system and how bus contracts (e.g. share of profits) will be organized in MaaS model, (Hensher, 2017).

According to the experiences from Germany and Switzerland, car-sharing acts as a strong supplement for public transport and it also enables giving up car ownership, which further increases the use of public transport (Becker et al., 2017b; Huwer, 2004). Without carsharing option, public transport oriented lifestyle could be difficult to maintain (Huwer, 2004).

Furthermore, residential area's enhanced accessibility has a connection to a decreasing number of privately owned cars and an increasing number of season tickets for public transport (Becker et al., 2017b). Purchasing a car or giving it up reflects a lifestyle change resulting in changes in mobility behavior, (Huwer, 2004).

1.5.3. The role of cycling in MaaS

The discussion about the role of cycling under the MaaS model is missing in almost all MaaSrelated literature. It has been mentioned that bikesharing is an important part of a comprehensive service system (e.g. Ambrosino et al., 2016; Kamargianni et al., 2016), but discussion has focused on other transport modes, especially on private cars, car-sharing, taxis and public transport. Yet, free-floating bike-sharing services offer an easy way to use bikes as the system includes several pick up and drop off points, and because of environmental aspects promoting bike-sharing is worthwhile (Tomaras et al., 2017).

Observations related to bike-sharing systems reveal that bike trips are typically short (usually less than 10 minutes) and this relates especially to most active users (Caulfield et al., 2017; Tomaras et al., 2017). Furthermore, active bike-sharing system next to fixed bus route has been assessed to decrease bus ridership in New York City (Campbell & Brakewood, 2017). However, in these studies bike-sharing has been studied as separate system from MaaS. It would be meaningful to understand the role of bike-sharing compared to expectable cornerstones of service system e.g. car-sharing and ride-sharing services. Current bike-sharing users would be likely users of MaaS as bike-sharing members have been assessed to be more willingness to try new services (e.g. flexible public transport) compared to others (Frei et al., 2017).

It is still unclear what will be the role of cycling as we are lacking proper knowhow of larger scale MaaS schemes. On one hand, bike-sharing services could increase the amount of cycling trips as bike can be chosen for only one part of the trip chain and the bike is easy to access from multiple stations by using credit card or smart phone. On the other hand, carsharing services offer easy access to automobiles, and ride-sharing services provide lower cost mobility. These are comparable choices for bike-sharing. Ride-sharing and demand responsive transport also offer more applicable pick up points for passengers compared to current public transport, which decrease the walking distances to access these modes. In conclusion, new services promote mobility possibilities in several ways, which make it hard to predict what is the future role of cycling.

1.5.4. The role of transport hubs (airports, ports and stations) in MaaS

--- key examples from AMS, ATH, MUC, OSLO, GENEVA

1.6. Drivers and Barriers for Mobility as a Service

Legislation

Government has an important role in relation to integrated mobility services both related to creating preconditions for implementing IMS, and to protecting public interest. Goodall et al. (2017) point to the importance of the government to safe-guard safety and security as well as addressing environmental concerns. However, it is key to find the right level of regulations, where the public interest is served, but where the private sector still finds it easy to participate and innovate (ibid.). According to König et al. (2016), the focus of regulation should be in "ensuring transparent market conditions and fair market performance and securing the legal position of consumers and travellers". Legislation in many countries today acts as barrier for innovation and change in the transport sector, with regulations concerning e.g. the taxi market, who has the right to sell tickets for public transport etc (Trafikanalys 2016).

Ticketing

An important issue relates to the subsidization of tickets for public transport. In Sweden as well as in many other countries, public transport tickets are subsidized by the state, which has implications for how public transport operators are allowed to sell their tickets. Furthermore, if IMS means that many different forms of mobility services are combined, the boundaries between public transport and other services such as taxi, carpooling etc become blurred, which may have implications for which mobility services it is reasonable to subsidize (Trafikanalys 2016).

District boundaries

An important question hence concerns the boundaries between state subsidized mobility services and commercially viable services, and how these can be combined in IMS solutions (Finger et al, eds., 2015). In the case of the Ubigo trial in Gothenburg in 2014, one of the main barriers for continuing the service after the pilot phase was that due to present laws and regulations the public transport operator could not continue as a service provider in a regular business context (Karlsson et al. 2016). In Sweden, many municipalities perceive national legislation does not give them the right to allow carsharing stations on public land, as this would violate the principle of treating all citizens equally (Trafikanalys 2016). This creates a barrier for municipalities who wish to support the spread of carsharing services, allegedly an important part of most IMS solutions being discussed. However, a recent public inquiry on measures to promote circular economy in Sweden suggests that this legislation should be changed (SOU 2017:22).

Sharing economy

The extent to which the development of IMS is perceived to be a threat to the current models for taxation and financing of infrastructure, as well as models for collecting revenue from existing transport services, may constitute a barrier for supporting innovation. However, new transport services are likely to present new opportunities for revenue and tax income, perhaps based on data from connected travellers' actual infrastructure use and time of use (McKinsey&Company, Bloomberg New Energy Finance 2016). In Sweden, several investigations are right now looking into the implications of the new sharing economy

(Trafikanalys 2016). The Swedish Tax Agency has performed a mapping of tax-related effects of the sharing economy, and concluded that on the one hand there is no reason to tax peer-topeer services at a lower level than traditional services, but that on the other hand there is a risk that complex regulations increase the risk for mistakes, especially as control of peer-to-peer transactions is low (Skatteverket 2016).

Tax legislation

This may consist the greater barriers for behavioural change. In Sweden, current tax-legislation for subsidized company cars constitute a significant lock-in factor for commuters to continue travelling by private car (Holmberg et al. 2016). This legislation is now up for change, with suggested alterations in the proposed budget for next year increasing the costs for individual users with potentially hundreds of Euro/month (DN 2017-03-27). Such a change may contribute to increased demand for new mobility services 2.1.3. Financing König et al. (2016) identify a major role for the public sector as an enabler of IMS pilots. Goodall et al. (2017) also point out the opportunity for governments to support the development of new, integrated mobility services through establishing governmental programs. Karlsson et al. (2016) conclude that for the Ubigo trial in Gothenburg, one of the barriers for continuation was the lack of financial support. Although the pilot was successful, and a company was formed, neither of the stakeholders involved, nor governmental financial bodies were able to support further development, primarily because of institutional barriers.

Data availability and standardization

The rapid development within IT and smart cities, with integration of different forms of open data is a necessary precondition for the development of integrated mobility services (Hultén, ed., 2016). König et al. (2016) similarly point to working ICT infrastructure and open APIs as vital elements in making IMS a reality, but also intelligent and connected infrastructure. Standardization of data is hence one important role for the state to enable the development of IMS (Finger et al, eds., 2015).

Data use legislation - GDPR Framework

1.7. Mobility as a Service Future Challenges

1.7.1. Demand – Side Modelling

1.7.2. Supply - Side Modelling

1.7.3. Governance and Business Model

Chapter 2. Car sharing

The Chapter will focus on the well-established practice of car sharing. The different models that exist on car sharing will be analysed and presented. Some good practices / case studies will be illustrated as well as some business models will be analysed in details. The interaction of car sharing market with other markets providing mobility as a service such as bikes and railways will be provided. The challenges and the trends for the future will be addressed.

2.1. Introduction

2.2. Car sharing models

2.3. Car sharing business cases

2.4. Good practices and Case studies

2.5. Challenges and trends

2.6. Conclusions

Chapter 3.
Bike sharing

Chapter 3 will provide an analysis on bike sharing. As it is the case of car sharing, bike sharing is a well-established practice and operates in many cities. Case studies from different cities will be analysed and presented. Business models on bike sharing will be illustrated and analysed with the scope to identify good practices. The THE PEP masterplan on cycling promotion will be presented. The interaction of the bike sharing models with other mobility as a service practices will be illustrated and analysed.

3.1. Introduction

3.2. Bike sharing models

3.3. Bike sharing business cases

3.4. Good practices and Case studies

3.5. Cycling Master Plans

3.6. Challenges and trends

3.7. Conclusions

Chapter 4.
Railways and Mobility as a Service

Chapter 4 will present the new business model for railways which is the provision of integrated and door to door services. These services include bike sharing, scooter sharing, car sharing, bus sharing, car pooling, park sharing, hotels, taxi, stations for electric cars, intermodal services such as rail and air or rail and ferries, public transport, events etc.

Platforms that integrate all these services and connect them with the rail transportation are needed in order to operate such as MaaS for railways.

The Chapter will include case studies with railways that have already implemented such packages and good practices.

Chapter 5.
Enablers of Mobility as a Service operators (Mrs. Stefanie Pichler, Fluidtime)

5.1 Introduction

For MaaS to deliver its potentially huge positive impact, it must add value for all stakeholders – mobility users, private and public transport operators, MaaS providers, cities and regions. Creating viable business models is crucial. Without being able to meet the needs and aspirations of mobility users, making it interesting for transport operators to be part of a MaaS service, or creating enough value to build a successful business, MaaS will not succeed.

Despite all transport services and usage of IT to streamline the individual services, the mobility market is quite conservative when it comes to open up and co-operate between actors. More and more transport operators are entering the market and offering various mobility options, such as car sharing, bike sharing, public transport, etc. The result is a fragmented mobility ecosystem with a big variety of operators working in silo – A situation that leads to a variety of problems for all involved. As for public authorities, the problem is, that private transport operators initially focus on market growth and profitability rather than on environmental and climate protection when they enter a new market. The largely uncontrolled introduction and expansion of sharing services has led to persistent space and traffic problems in cities, the harmful effects of which are borne by the general public, often without accountability and compensation (Sherman, 2017). For this reason, public authorities of cities and regions interested in providing intelligent mobility to their inhabitants are also looking for ways to coordinate their urban mobility systems and maintain control over a fair mobility market where transport operators can compete on equal terms and where the same rules and conditions apply to all market participants. In addition, public authorities are missing a valuable source of data that they can use to improve urban mobility, as they lack a platform for exchanging information and for analysis. They receive no information on which modality is used when, in what intensity and in what situation. However, experience with the user behavior of additional mobility services would be essential information that should be incorporated into urban transport planning.

Looking at mobility customers, we can see that fragmented mobility provision is a major problem for these market participants. As an example, in the city of Vienna, Austria, with about 1,8 Million inhabitants there are more than 20 transport operators focusing on shared mobility. Each one is built vertically – their own products are offered through their own app – with limited linking to other transport services. In order to use them, mobility users need to register, input and manage sensitive data such as their addresses, phone numbers and payment details. To do so across multiple apps is a hassle, it’s also hard to combine the products from one provider with those from another. Apart from the common integration of "walking" as a typical entry and exit mobility mode, all this transport services lack information for intermodal journeys. As they are not integrated with other transport modes, especially with public transport, this makes it for mobility users increasingly complex to decide which services would fit best to travel from A to B. At best, it results in using various mobility services – usually simultaneously – to find information, purchase and access different transport modes. (Kamargianni/Matyas 2017) In the worst case they use the most comfortable means of transport, i.e. often their own private car. To increase the satisfaction of mobility customers with new mobility offerings and to accept them as everyday mobility, an easy-to-use application with integrated mobility offers that meets all their needs is required. In short, they want MaaS in their lives, even if they don't know it yet.

At the same time, MaaS providers offering MaaS services to mobility users are looking for a tool to implement a sustainable business model and facilitate the integration process of transport operators on their mobility platform. In order to initiate an integration process, a MaaS provider must first contact and agree common terms and conditions with the desired transport operator to ensure secure use of the transport operator's data, as well as include pricing agreements and prepare this data for integration into its service. A very intensive process for the MaaS provider that takes both time and budget. As the costs for each transport service integration are even higher when entering each mobility market separately, an amortization of costs and economies of scale is desirable for MaaS providers. If this is not the case, it could be difficult to offer mobility users low-cost mobility packages.

With the introduction of a MaaS platform enabler, a platform technology for solving their existing problems in the mobility market can be found, especially for MaaS providers, but also for other actors from the ecosystem. It helps to support, if not accelerate, the achievement of the goals of the respective stakeholders. It also enables and facilitates new mobility and keeps the cost of developing and operating new MaaS solutions low.

5.2 The MaaS ecosystem and its key stakeholders

When travellers combine different transport services that they can book and pay for directly through the app, multiple players come together, all part of an integrated MaaS ecosystem. An interaction between them is necessary in order to enable a truly intermodal MaaS solution. Basically, it can be distinguished between MaaS providers, transport operators, public authorities of cities and regions as well as enabling services and mobility customers, mainly commuters who use transport services for their daily travel arrangement. For each role those stakeholders are playing, a particular profile with corresponding interests and expectations from other roles can be associated. The MaaS ecosystem is complex with very different types of (in itself non-digital) services and with different conditions in each city.

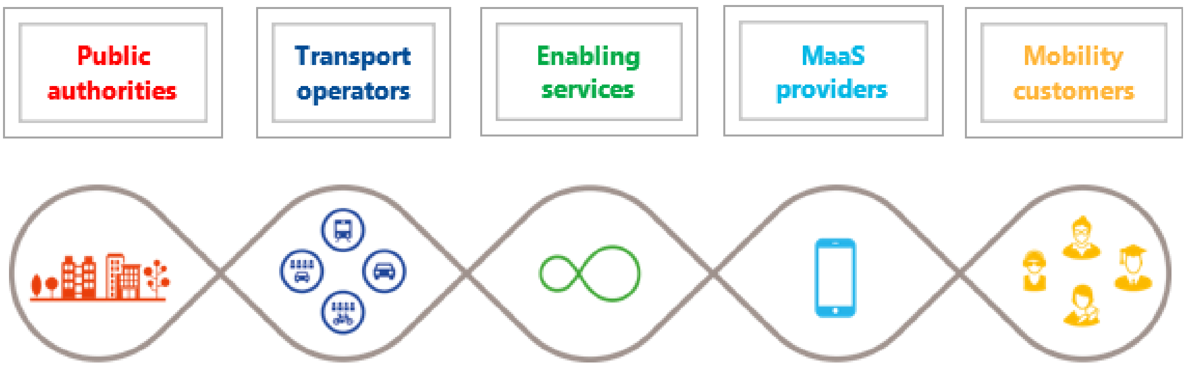

Figure 5.1: The MaaS ecosystem and its stakeholders (Fluidtime, 2019)

5.2.1 Public authorities

Public authorities are in charge of local transportation such as city and state governments or public transport authorities. Perhaps their most important goal is to establish a MaaS ecosystem and actively govern it through measures designed to correct issues, enhance the exchange of transport services and reach the mobility-related, economic or societal goals the city has. In addition, they structure the mobility ecosystem in such a way that, despite conflicting interests, it is beneficial for all parties involved. There may be conflicting interests between cities and transport operators in terms of objectives (improvement of the urban environment vs. market growth), and in terms of integration and management of public and private transport operators within the same ecosystem, but also between transport operators and MaaS providers in terms of data ownership. In general, data is scarce and not consolidated by public authorities due to a lack of IT systems. Furthermore, new technologies of transport operators are largely unknown and not yet regulated by law.

5.2.2 Transport operators

Transport operators, in further consequence also called transport service providers (TSPs), are operators of the physical transport service such as public transport, car sharing, taxi or demand responsive transport. The latter is a special need transportation for students, elderly or disabled people in cities and furthermore shared on demand busses or taxis in rural areas where other mobility modes are unavailable. A transport operator can either offer its service exclusively to its clients or can complement it with additional services e.g. a bike sharing application shows public transport lines next to its bike sharing stations on the same map to facilitate users' trip planning. In order to integrate a transport operator into a MaaS provider's mobility platform, its data has to become accessible, but the depth of integration varies. Not all transport operators can offer the same integration depth. Due to their political (market strategy) or IT constraints (insufficient communication regarding API documentation, incomplete APIs, invalid certificates), working with various transport operators can make it difficult or prolong the introduction of new MaaS solutions and place a financial burden on their ongoing operations. By integrating transport operators into mobility platforms, they are able to open up new markets – either geographically to which they can extend their business or by providing new services – and consequently win new customers. They are able to optimize their services and operations based on the demand and supply data generated.

5.2.3 Enabling services

Enabling services are entities that support either the establishment of a mobility platform for MaaS services or the orchestration of a MaaS ecosystem in general. A MaaS provider integrates routing, booking or payment services as well as customer management systems on its mobility platform that are essential for operating a proper MaaS solution within the ecosystem. In Chapter 4, we will focus in detail on the MaaS platform technology provider as this type of enabling service provider delivers essential functionality for MaaS providers.

5.2.4 Mobility customer

Based on the MaaS provider's business model, mobility customers or user can be individuals, commuters or city dwellers, as well as companies and their employees. (Kamargianni/Matyas 2017) In those cities and regions in which public transport does not yet have the status of a seamless continuous journey for commuters and residents, more and more transport operators are entering the market and offering new and innovative means of transport such as car, bike or scooter sharing as well as carpooling, ride hailing, and so on. The result is a heavily fragmented mobility market with many service operators, making it hard for the end user to choose the best travel option. Another consequence of the heavy fragmentation is the impossibility of providing a good travel experience; the mobility customer must consult multiple apps provided by different transport operators to plan a door-to-door trip, collect travel information in private and book services separately. This complexity is a drawback for public and private transportation modes and pushes the end user toward using its own car.

5.2.5 MaaS provider

A MaaS provider is an entity facing the customer, to which they provide a mobility service, such as public transport for its passengers, a corporate group willing to improve the travel expenses and travel behavior of its employees or a public authority aiming to foster sustainable travels in its city or region. A MaaS provider acts as an intermediary between transport operators and mobility customers: It integrates the data of the individual transport operators on a mobility platform, buys capacities from the transport companies and sells them on to the users. Mobility customers only use a single app to find information and select the preferred means of transport for their journeys – a concept known from other sectors such as tourism or retail. “The MaaS provider can propose the ideal combination of transport modes to them for each trip by knowing the network conditions in real time (supply side) and the preferences of users (demand side). In other words, the MaaS provider can optimize the supply and the demand”. (Kamargianni/Matyas 2017). Depending on function and goal, MaaS providers offer solutions for businesses (B2B), for mobility customers (B2C), for companies and their employees (B2E) or for public-private partnerships (PPP). Since commuting between different cities is common in most regions due to housing prices and quality of life, MaaS can be seen not only as bridging the gap between transport operators in the same city, but also between different cities and initiates the idea of "roaming” in the transport sector. (Kamargianni/Matyas 2017).

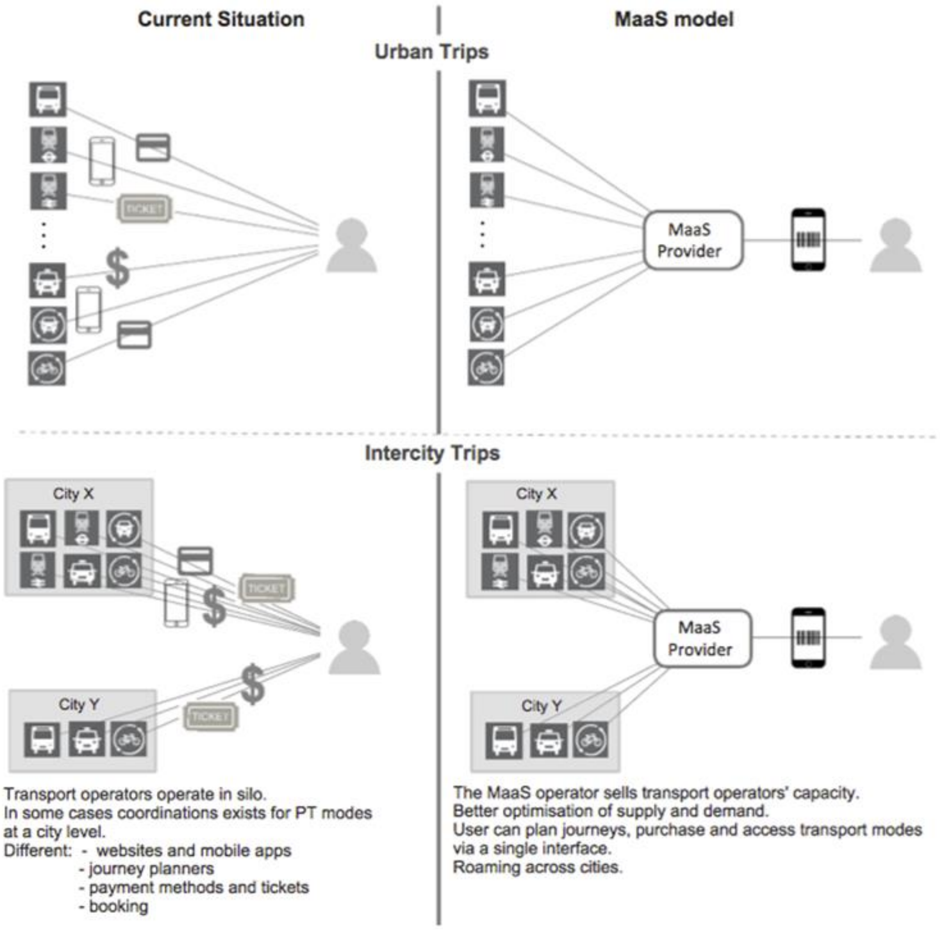

Figure 5.2 The Role of MaaS providers (Kamargianni/Matyas 2017)

As shown in Figure 5.2, a MaaS provider is all the more important when it comes to offering solutions for intercity trips. With MaaS solutions they facilitate all steps from travel planning to booking combined forms of mobility, minimizing the burden on the mobility customer, and this very heterogeneous environment leads to significant integration and maintenance costs when setting up a MaaS service.

5.3 Barriers & obstacles of MaaS providers

The mobility landscape consists of a big variety of transport operators giving potentially lots of options to solve daily mobility needs. This number is luckily even increase due to additional ridesharing services and demand responsive transport services acting as complimentary opportunities to solve the user’s last/first mile issues. However, this variety of transport operators makes it hard for the mobility customer to find the services that would fit best to their mobility demand. As MaaS services are introduced to mobility customers to overcome their reluctance to use mobility alternatives, MaaS operators are struggling with fragmentation, integration costs and time management problems on the supply side of MaaS. Those issues have a significant impact on the successful introduction and maintenance of new services.

5.3.1 Fragmentation

Fragmentation can affect both MaaS providers and public authorities in the MaaS ecosystem. A mix of transport operators complicates the integration process for MaaS providers because they provide fragmented and inconsistent data due to different development states and technological standards. For public authorities, the mobility infrastructure is fragmented as it comprises a number of stakeholders with different solutions that make it difficult for them to distinguish between mobility offers and to keep track of all parties involved, their functioning and supply structures.

5.3.2 Integration costs

To succeed with MaaS and diminish the need of using a private car for daily routes, a critical amount of transport operators within a local mobility market offering combined mobility options is required. From a technical perspective, MaaS providers are facing a multitude of interfaces with different data standards, technologies and supported capabilities – not just between different modes of transport, but also when comparing the two operators of the same modality. And this highly heterogenic environment finally leads to substantial costs for integration and maintenance when setting up a mobility platform for a MaaS service, most often ending in a non-viable business case when considering the full costs.

5.3.3 Time investments

When entering highly competitive markets, a MaaS provider faces a variety of time-consuming challenges before launching its solution. In addition to the monetary burden, integration processes also require a considerable amount of time. They have to contact different transport operators, which are differently receptive to the topic of MaaS depending on their market and growth strategy. Once a cooperation has been decided on, they must define common terms and conditions for their partnerships and prepare the integration process on both sides. A process that can take several months. In addition, investors and partners are important factors in establishing MaaS and coordination with administrative authorities and local institutions should not be underestimated either. Entering a new market always means being confronted with political and governmental obstacles, such as the new laws and guidelines to introduce free-floating bike sharing in Vienna or Singapore[1]. All these time-consuming factors can lead to the fact that the competition with a similar solution gains a foothold in the market faster and ties important customer segments to itself.

5.3.4 How to accelerate and streamline MaaS

To enable end-users to benefit from seamless door-to-door mobility, an efficient mobility platform is needed that adapts travelers' choices and offers mobility alternatives offered by as many integrated transport operators as possible. In its deployment, a MaaS provider benefits from the use of a MaaS platform technology to accelerate and optimize the journey from the integration of transport services and additional enabling services (booking, payment) on its mobility platform to the rollout and operation of its MaaS solution. Another use case for a MaaS platform technology sees the public authorities as the main beneficiaries, as it provides them with an instrument for regulating the mobility market and urban planning. Both use cases as well as the key functionalities of the mentioned MaaS platform technology will be explained in the following section.

5.4 Role of the MaaS platform technology provider

A MaaS platform technology provider offers the means to either build-up a B2C MaaS Service operated by a MaaS provider or establish a B2B MaaS ecosystem orchestrated by public authorities. Relating to the latter, the MaaS platform provider supports public authorities of cities and regions in orchestrating the ecosystem and support local transport operators in optimizing their current services and processes. Authorities get a holistic overview of the local mobility offer and the tools to improve, regulate and control the existing mobility ecosystem that is based on a collaborative MaaS platform.

For MaaS providers, the use of a MaaS platform technology solves the fragmentation problem of the transportation market and enables them to offer end-users seamless door-to-door mobility. The platform technology enables MaaS providers to set up their mobility platform with key components such as central access for all types of mobility, simplified contracting and efficient and transparent management of transport operators, including usage-based billing.

By using a MaaS platform technology to deploy MaaS, public authorities, MaaS providers and transport operators benefit directly as they profit from daily operations, continuous updates, service monitoring and a certain level of warranty. The product architecture offers high availability and stability and enables rapid extensibility and flexibility to meet customer needs. The architecture is also highly scalable and supports multi-tier rollouts. Mobility customers will also benefit as new MaaS solutions emerge that make their personal integrated mobility more attractive and reduce their need to use a private vehicle for their daily journeys. As a result, roads will become cleaner, parking will be calmer, and the environment will recover from pollution and noise.

5.4.1 Key functions of a MaaS platform technology

The main impediment towards the wide-scale provision of seamless travel to customers is the fragmentation in the offering of mobility products. To address this situation, the MaaS platform technology enables the mobility platform of MaaS providers to offer uniform and

[1] Under the new laws in Singapore, bike-sharing operators have to be licensed by the Land Transport Authority (LTA), which will regulate their fleet sizes (Cf. LTA, 2018). With a new regulation since 2018, Vienna limits the fleet size to 1.500 bikes per provider and imposes fines if inappropriately parked bikes are not removed within a certain period of time (cf. ordinance of the city of Vienna, 2018).

standardized access to the products and services of all integrated transport operators. This lays the foundation for an open and collaborative MaaS ecosystem, see Figure 5.3 below. Transport operators integrate their services into the MaaS platform. They can improve their operations based on new insights about end users' service needs and service preferences. By being integrated into various MaaS solutions, transport operators gain access to new markets or customer segments.

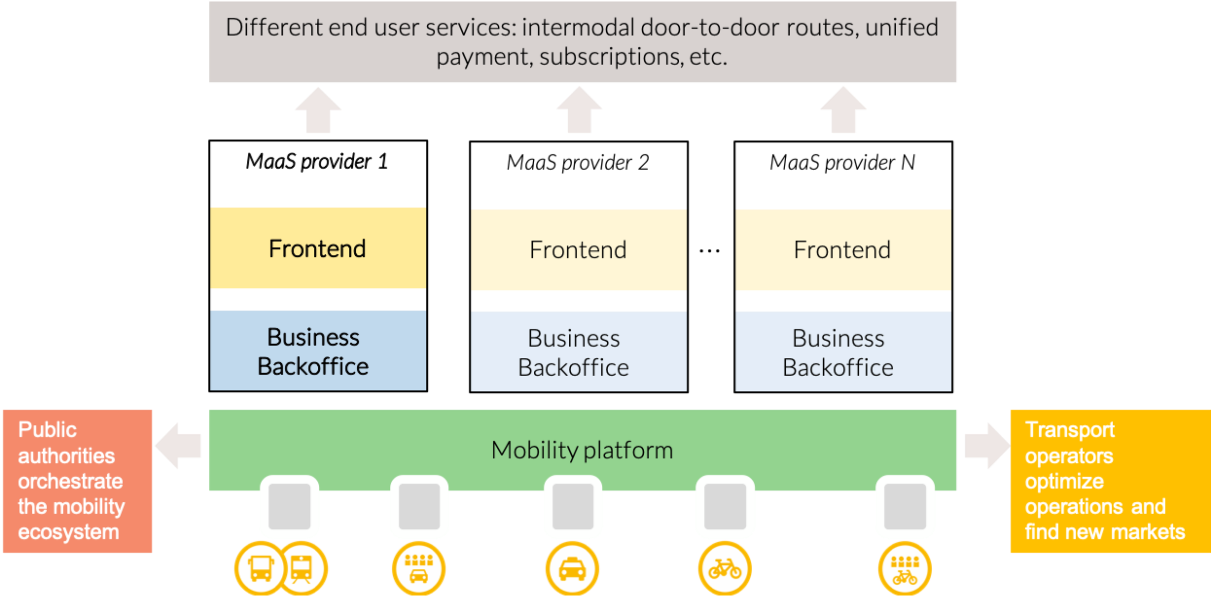

Figure 5.3 Illustration of a collaborative MaaS ecosystem (Fluidtime, 2019)

At the same time, public authorities get a tool to orchestrate the mobility ecosystem. They get access to reports and statistics that they can use for strategic traffic planning. Cities can encourage multiple MaaS providers to deploy different MaaS services without having to integrate transport operators separately for each service. Once integrated, all transport operators are available on a city’s mobility platform and just need to be enabled for new MaaS services.

The platform technology enables the MaaS platform to act as a standardization layer by harmonizing data from multiple transport operators, making it available to the MaaS provider and thus providing seamless access to locally available mobility offerings.

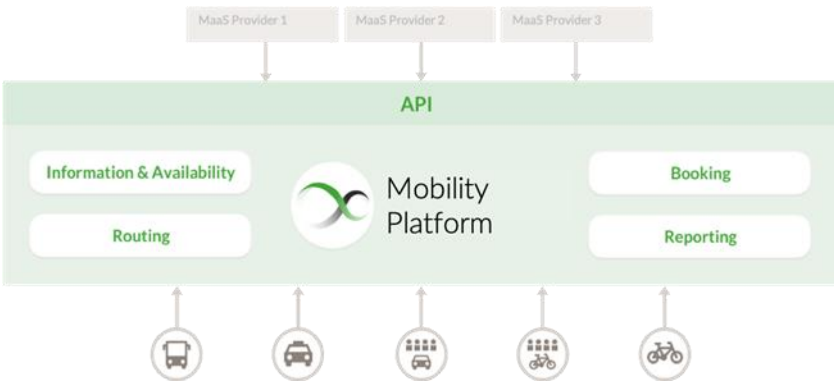

Figure 5.4 Overview of the functionalities of a technology-driven MaaS platform (Fluidtime, 2019)

As seen in Figure 5.4, a MaaS platform technology enables to set up a smart mobility platform with the main components Information, Availability, Routing and Booking. How these functions work in a smart MaaS platform will be described in the following sections.

5.4.1.1 Information and Availability

Specific data provided by transport operators are imported via technical interfaces (APIs). In case the transport operator cannot provide such APIs, as is the case for some smaller car or bike rental services, the data can be imported manually. The MaaS platform uses dynamic data by default. Real-time information is given by external providers and is used for different functionalities such as showing transportation availability, routing as well as current services and offers. The end user benefits from up-to-date public or private transportation schedules and is warned of possible traffic or service disruptions, construction sites, weather effects, scheduled or unscheduled maintenance work, etc. via the frontend app. In addition, static data including information about available transportation lines and stations, planned transportation schedules, hours of transportation service or retail offices is used whenever dynamic data is not available. Beside metadata, location data is supported to determine transportation availability for the end users. In this context, a location is defined as a geographical point where there is a possibility of transportation services, be it static (bus stop) or dynamic (parked shared car or a pick-up point for ride hailing). A location can also be a Point of Interest (POI) such as a monument, an important building or a social hotspot. Locations can be uploaded to the system either by the transport operators themselves or by other parties involved.

The MaaS provider decides which features they want to enable or disable for their MaaS service. Depending on the means of transport offered, different data and services are made available by the transport operators. Table 1 shows which modes of transportation are supported to what extend in the mobility platform.

Table 5.1 Data overview from transport operators integrated in the mobility platform

Mode of transportation	Information	Routing	Booking	Reporting
General data	Third-party information about services with locations	Third-party info such as weather, traffic, etc. comprised in route results	-	Comprehensive reporting features based on user interaction with respect to transportation availability, routing and booking
Car/Bike/Scooter Sharing	Location, vehicle information (type, engine, fuel/ charge state), station details, availability, price schemes	Sharing options are considered in route results, i.e. walk to bike sharing station	Booking, cancellation, access service (to unlock a vehicle), tariff scheme, pricing	
Public Transport	Routes, trips, stops, arrival and departure times, service intervals, real-time incidents and delays, tickets,	Routing information (routing & monitor service), trips, stops	Booking/ ticketing (reservation and cancellation), tariff schemes, lists of provided tickets	

Ride Sharing	Locations, vehicle and driver info, price schemes	Pick-up and arrival times	Booking, cancellation, tariff scheme, pricing, booking info	
Ride Hailing	Locations, vehicle and driver info, price schemes	Pick-up and arrival times	Booking, cancellation, tariff scheme, pricing, booking info	
Car/Bike/ Scooter Renting	Locations, hours, available vehicles, additional info (e.g. pricing, insurance)	Routing based on these transport modalities	Booking, cancellation, tariff scheme, pricing, booking info	
Taxis	Locations, vehicle and driver info, pick-up and arrival times, price schemes	Pick-up and arrival times	Booking, cancellation, tariff scheme, pricing, booking info	
Demand-Responsive Transport (DRT)	Locations, vehicle and driver info, pick-up and arrival time, price schemes	Vehicle, driver and pickup point are route-specific	Booking, cancellation, tariff scheme, pricing info	
Parking & Charging	Car and parking lot location, capacity, availability, price schemes	Lot location is considered for routing, i.e. walk to the car park	Booking, cancellation, tariff schemes, pricing	

On the information level, transport operators provide data such as location of the vehicles, price schemes, transport stops, pick-up/drop-off locations and capacity. Users can either find information on the operator's website or in a provided application. The routing level allows mobility users to plan their trips from A to B. Beside the basic information of the transport operator, users get recommendations for different route options depending on the preset preferences for walking speed, maximum of walking distance, waiting time and number of transfers. The MaaS platform enables the calculation of intermodal and multimodal travel routes via external routing providers tailored to specific modes of transport; it also includes additional functions such as reporting and data analysis. Once integrated, all transport operators' data can be deployed to different MaaS solutions for multiple locations or multiple end-user segments.

5.4.1.2 Routing

The MaaS platform enables seamless door-to-door trips. It does so by interconnecting available transport offerings based on locally established routing engines. Intermodal route calculation is a key feature, as it creates routes which use several modes of transportation across multiple transport operators. Overlapping business areas, i.e. areas where the transport offerings overlap, result in the richest availability for the end user, see Figure 5.5. In areas where business does not overlap, intermodal routing opens up new transport opportunities for end-users and quickly exploits geographical areas that were previously accessible with only one means of transport by adding a second means of transport to the journey.

Figure 5.5 Different forms of intermodal routing

5.4.1.3 Operation setup: Booking, Ticketing, Payment

Booking of different transport services in one central system are enabled via the MaaS platform. On the frontend side, this means that mobility customers can book all mobility offerings through one single sales channel. Various booking workflows are implemented for this purpose, namely route and product-related booking. Bookings are performed through the standardized APIs, which allows full integration of products and services from transport operators. A product-catalogue can be put together and consolidated across all transport operators.

Four types of products are supported, namely:

- Vehicle-based: car-/bike-/scooter- sharing/rental, etc.
- Route-based: taxi, hailing, DRT, public transport, etc.
- Tickets: public transport, etc.
- Parking and charging services

Another platform function is booking cancellation. Cancellation requests will be forwarded to the booked transport operators while refunds and cancellation fees depending on the predefined business rules will be forwarded to the mobility customer. Current and upcoming bookings as well as a user’s booking history are listed and managed via the mobility platform’s back office. To ensure the bookings are always up to date, the booking details are retrieved from the database and synchronized with the transport operators’ systems.

An implemented pricing engine makes it possible to create new prices for transport services and products. The new price can be based on the price provided by the transport operator, including mark-ups and deductions, or can be the result of an individual price calculation, e.g. a new calculated price, based on product-related attributes such as duration, length or service category.

In terms of ticketing, the MaaS platform uses ticketing APIs that enable integration with existing ticketing solutions or new ticketing solutions are developed and integrated. NFC, QR codes and other validation features are supported and it is possible to extend technical solutions for existing or new validation mechanisms.

Depending on the available data and whether the transport operator fulfills the technological requirements for this, a MaaS provider can choose from different payment modalities for its MaaS solution. The different levels of extension are listed hereunder:

1. **Information and routing**: the listing of locations, products and offerings of transport operators is available within the mobility platform. For example, the locations of

free-floating shared cars are available. Locations and services are used for creating intermodal routes. For example, upon sending a routing request, the mobility customer receives an intermodal route using the free-floating shared cars in point. On this extension level, no payment option is available.

2. **Direct Booking**: transport offerings can be booked directly. For example, the mobility customer can book the free-floating shared car he's already gotten during the routing step.

3. **Pay-as-you-go**: transport offerings can be paid on the go by the mobility customer. For example, the user performs a one-time payment of the car he booked for his route.

4. **Account-based billing and payment**: transport offerings can be paid through bills coming at pre-determined time intervals to the mobility customer. For example, an end user gets a monthly bill for all the free-floating car sharing services he has used. The bill can obviously also comprise the sums invoiced for other modes of transportation.

5. **Subscription-based billing and payment**: The subscriptions and mobility packages a transport operator offers are available in the MaaS solution. For example, an end user can buy a 10-hour package of car sharing usage through the mobility platform from the transport operator.

As shown in the examples above, the extension levels build on each other, i.e. pay-as-you-go is only possible if direct booking is also enabled by the transport operator. Furthermore, the first three extension levels pertain rather technical functionality whereas the last three extension levels pertain rather financial/payment functions. Ideally, every transport operator offers all six extension levels. If this is the case, a MaaS provider can choose its desired extension level for each transport service it wants to comprise in its MaaS solution. If for example the desire is to show the availability of transportation near the user, it is enough to choose the first extension level, namely "Information and Availability", which allows the end user to see free cars and bikes nearby as well as nearby public transport stops, etc.

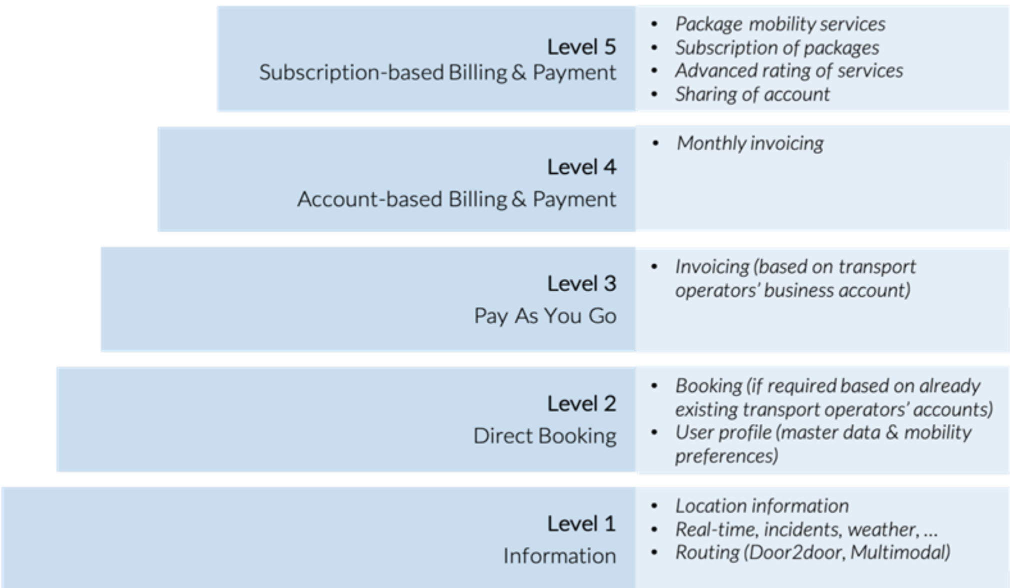

Figure 5.6 Extension Level Overview with regard to the payment options (Fluidtime, 2018)

5.4.1.4 Reporting

Through real-time streaming of mobility analytics data, the MaaS platform enables the integration into data warehouses and big data solutions. It offers comprehensive reporting features, enabling data drilling and promoting transparency. Its logging and reporting framework allow tracking all data it handles, e.g. transport service data, processing and enrichment of mobility information, transactions, bookings, end user behavior etc. This includes all information regarding requests, bookings and transactions it processes. A dashboard for the most relevant KPIs together with charts and diagrams support supports easy comprehension and analysis. Furthermore, all data can be exported to allow further processing and in-depth analysis by partners (e.g. investors, cooperation partners, cities) or integration into existing analytics and business intelligence services. Both real time and historical analyses can be conducted, since all data flowing through the system is logged. In addition, all demand and supply related data, including a mobility customer's full routing, booking and service history as well as provided services from transport operators for the individual requests are logged. This complete base of information allows the creation of any demand/supply reports. As an example, KPIs such as those presented in Figure 5.7 for the MaaS service UbiGo – the use case will be described in detail in the following section– can be created.

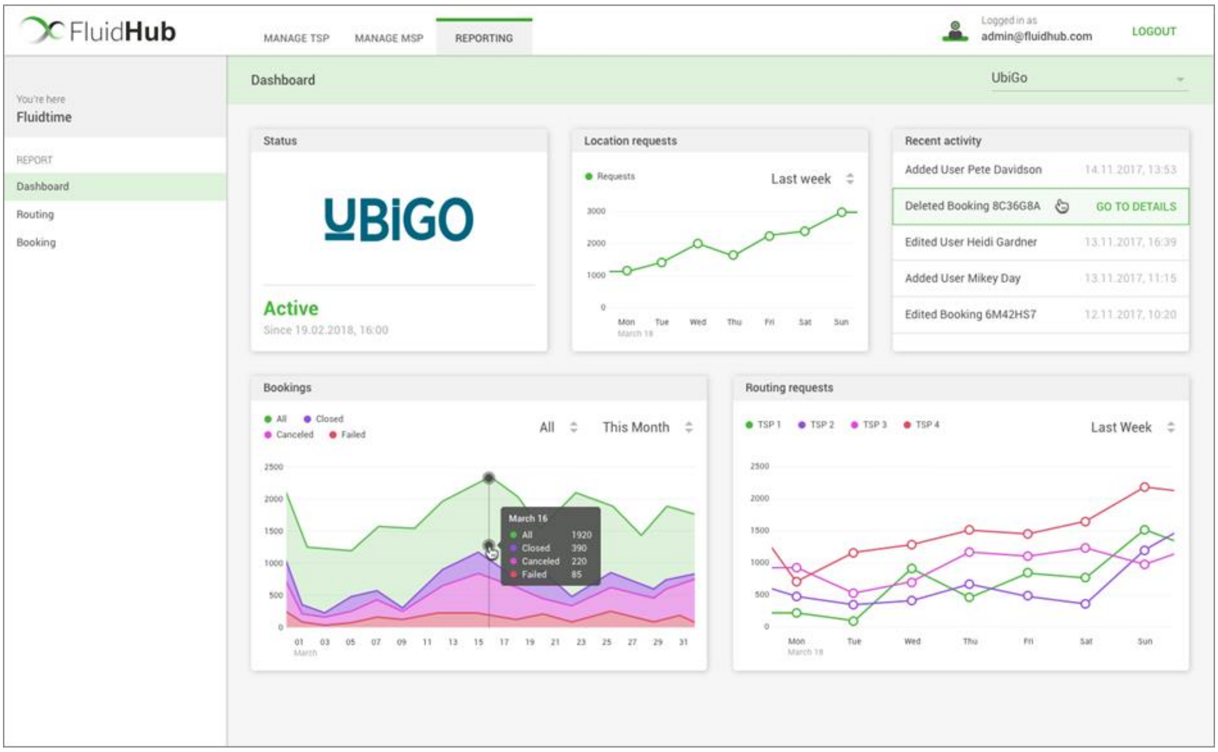

Figure 5.7 Reporting overview (Fluidtime, 2018)

5.4.2 Advantages for MaaS stakeholders

The mobility demand and supply from one region or city can be identified through a holistic view based on the capability to access anonymized usage data. Public authorities are able to analyze and orchestrate urban transport, find the right mix of means of transport and offer new services in the areas that need them. Cities and authorities will be empowered to manage transport operators in their geographical area of responsibility.

As well, transport operators can promote their products and offerings to multiple MaaS providers, who act as resellers; in this way, transport operators are enabled to reach new customers and target groups. Furthermore, they can optimize their services and operations based on the demand and supply data generated and also discover new geographical zones to which they can extend their business. As there will be different types of MaaS for different purposes and customer segments – commuters, businesses, tourists and other ad-hoc users, event companies etc. – a MaaS platform technology substantially reduces the integration effort MaaS providers must undertake, leading to lower setup costs and a faster time to market. Thus, it enables MaaS providers to focus purely on their core business, namely, to provide a compelling end-user service with an attractive USP: enable access to transportation information, routing and booking within an entire MaaS ecosystem via a single point of access.

Customers benefit from a variety of MaaS services, comprising door-to-door itineraries with integrated booking; the services will all have their distinct target groups and compelling USPs. The end users thus have a strong alternative to the private car, making car ownership less and less relevant.

5.5 MaaS areas of use

MaaS offers the opportunity to look at mobility needs as a whole. MaaS providers examine what kind of demand there is, what the target group needs to change their mobility habits and where there is a general mobility need, because MaaS means responding to different mobility demand models with different solutions. Different demand models listed below show that there are plenty of opportunities for mobility solutions that are not yet fully exploited.

1. **Business-to-customer (B2C)**: A MaaS solution is designed for travelers, commuters and residents of cities and regions to meet their mobility needs, such as seamless travel from A to B, easy book and pay for all integrated services and saving either money or time while traveling due to new mobility alternatives recommended by the MaaS solution. Private institutions as well as public institutions such as the urban public transport operator can become MaaS provider.

2. **Business-to-employee (B2E)**: often referred to as "corporate mobility". Companies are increasingly focusing on cost-efficient and sustainable travel management that takes employee expectations into account and is attractive to potential customers. The overall objective is to reduce the fleet and keep the cost of employee mobility low by offering mobility alternatives to more expensive corporate car journeys. An example of a MaaS solution is to provide an app with sharing mobility offers that are automatically billed via the company account. Ridesharing solutions can also be integrated on large company premises, e.g. to book a ride on the company shuttle.

3. **Business-to-business (B2B)**: A private company or institution wants to set-up a B2B MaaS platform to combine various transport operators with various MaaS providers. It can be seen as a networking platform aimed to foster MaaS in general.

4. **Public-Private-Partnership (PPP/3P-Model)**: A public-private partnership is an important construct that enables the establishment and operation of new mobility. It consists of collaboration between the public sector and at least one private sector. The public sector may support with cost reductions, legislative changes or the provision of a technically advanced smart mobility platform or ecosystem that accelerates the emergence of new MaaS solutions. The private sector provides the appropriate technologies and services to implement and operate them on an ongoing basis.

5.6 Case Studies

To shape a sustainable, flexible and eco-conscious future, it is decisive to break away from the existing standards of travel and think outside the box. Ridesharing is just one of many modes of transport that can be the key to better mobility within the MaaS ecosystem. Accompanied by mitigation strategies to limit car traffic and parking in cities, MaaS can become the major cornerstone to pull people into new mobility patterns. There are already cities and regions that show how an efficient MaaS ecosystem can be built. Due to their different starting situations, they have all found their own way to improve their local mobility situation with MaaS. Two exemplary cities are presented in the following part.

5.6.1 Stockholm

The Swedish capital Stockholm has a population of about 900,000 and about 2 million inhabitants in the metropolitan area. Almost 350,000 people are expected to move to Stockholm in the next ten years. Roads, subways and railways will have to be upgraded to support this regional development, but the transport needs within the city boundaries are likely to be greater than the physical capacity of the transport system. A significant proportion of all journeys in the region take place within the city. Stockholm employs around 570,000 people. Of these people, 54 percent live within the city limits and a further 22 percent in one of the ten neighboring municipalities. Efficient driving in a large city requires people to make most of their journeys by other means of transport. For the Stockholm transport system and for car traffic to function efficiently, the proportion of car journeys must be reduced. More people need to choose to walk, cycle and use public transport. (cf. City of Stockholm, Stockholm City Transport Authority, 2012) The Swedish capital has therefore opened up to innovative mobility opportunities, with UbiGo being the first solution of its kind to offer MaaS in the city. (UITP, 2019)

To accelerate the implementation of MaaS in Sweden, the B2C MaaS solution called UbiGo has been launched in Stockholm that provides citizens with a true MaaS experience for their daily routes. The MaaS solution combines public transport, car-sharing, rental car services and taxi to one intermodal on-demand mobility service. It is based on a flexible monthly subscription for mobility. As an example, the mobility budget can be shared within the family. Parents can share bike sharing points with their children, but limit taxi points. Each month a new mobility budget can be selected to suit current mobility needs. The larger the chosen package, the lower the basic price per hour for rental cars. If points remain, they can be taken into the following month. If there are no points left but the month is not over yet, mobility offerings can still be used at the normal rate and booked trips are simply listed separately on the monthly bill.

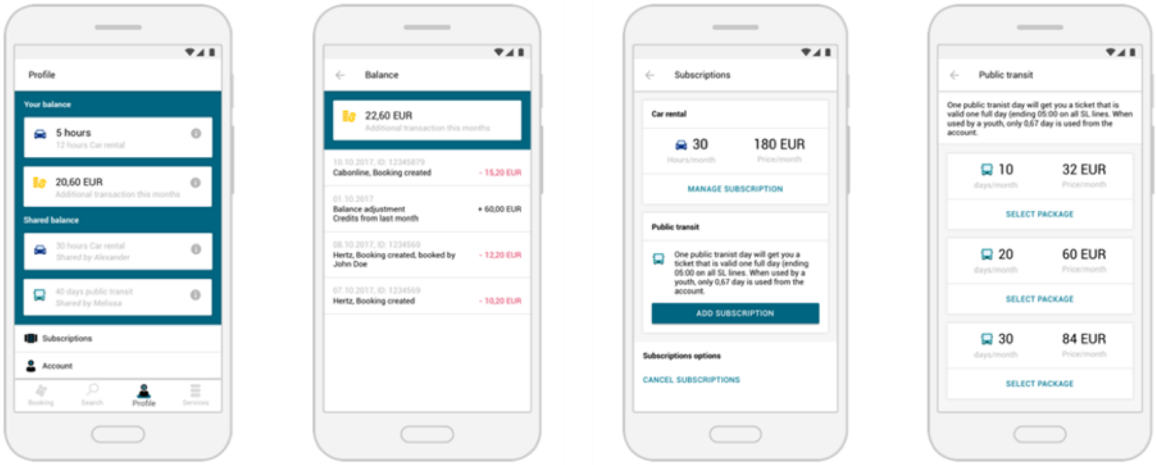

Figure 5.8 UbiGo – Profile, Balance, Subscription and Mobility packages (Fluidtime, 2018)

As a MaaS enabler within this project, the Austrian IT company Fluidtime Data Services GmbH offers its complete technology service stack from the frontend for the users, its platform technology FluidHub for the standardization of the integration process and simplification of the data management as well as the commercial back office for the administration of accounts, subscriptions and associated payments. UbiGo benefits from the full integration depth and was able to introduce its MaaS solution quickly and easily.

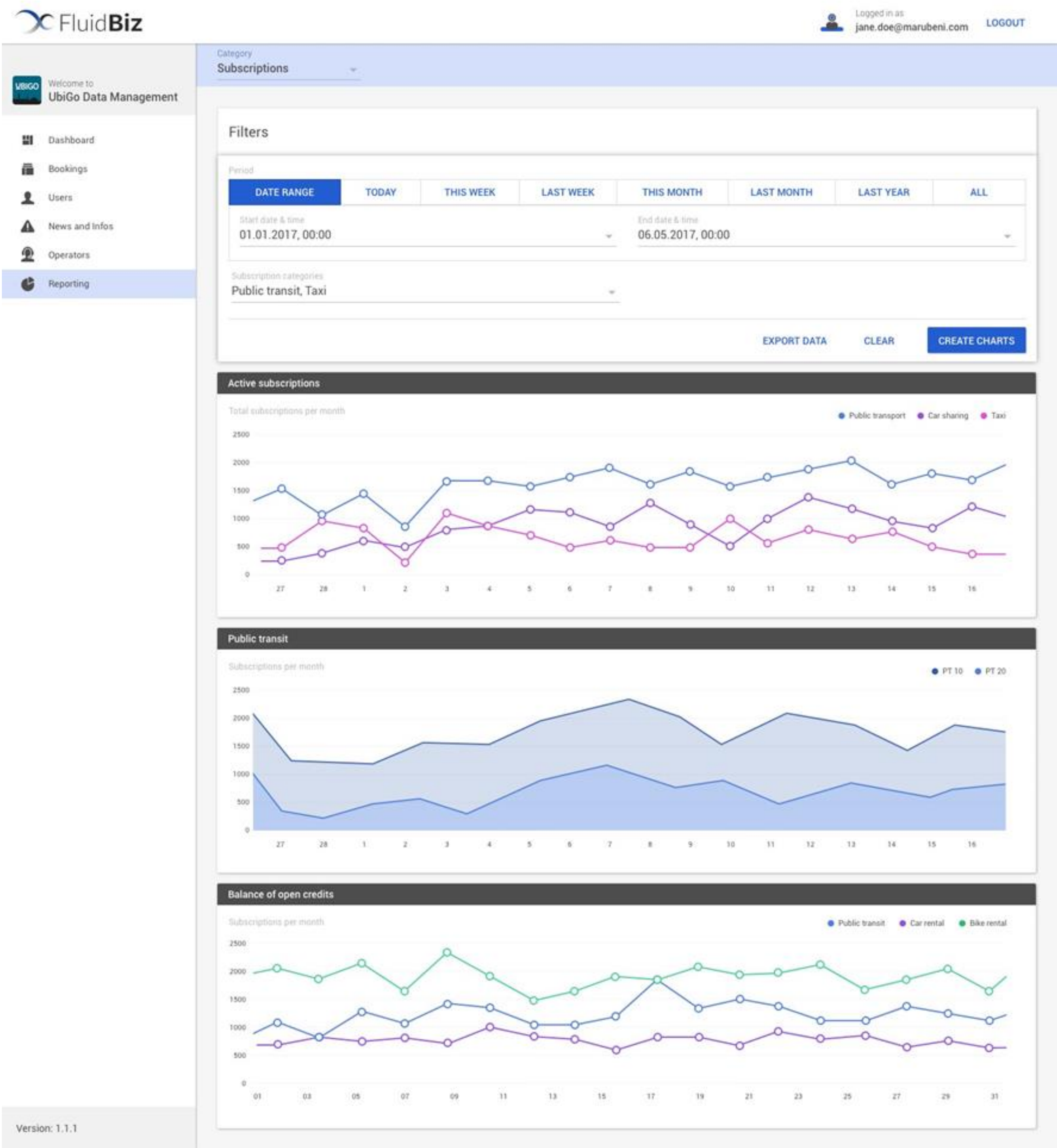

Figure 5.9 UbiGo Back office (Fluidtime, 2019)

UbiGo in Stockholm is based on the experiences gained within the very successful and thoroughly evaluated Go:Smart/UbiGo MaaS pilot project with 70 paying households (180 users) in 2014 in Gothenburg. These results and user experiences were incorporated into the further development of the MaaS solution, which has been implemented together with Fluidtime since 2017. After a test phase in summer 2018, UbiGo was launched in Stockholm in the following autumn. The MaaS service was introduced for around 200 external households in the city and will be fully operational in 2019 after evaluation and fine-tuning. UbiGo will use Fluidtime’s platform technology on an ongoing basis. This will enable the roll-out of UbiGo in Stockholm as well as its international and national expansion based on a franchise concept. In the future it will be possible to use a private UbiGo account (incl. mobility credit) in other UbiGo regions internationally.

5.6.2 Aarhus

The transport demand in Aarhus is increasing as the city is growing. During the last ten years, the number of inhabitants has increased by 11 % and the number of cars has increased by 27 %. Aarhus knew that it needs to implement sustainable mobility measures to give its inhabitants and commuters access to sustainable, comfortable and affordable mobility. Aarhus and its surrounding municipalities have an interesting, mixed context of dense urban areas and rural areas. It is an obvious setting to make a pilot project that demonstrates elements of a MaaS system focusing on ridesharing because it both contains the challenges of mobility found in cities and in the rural areas where the car still plays an important role in the mobility system. Ridesharing is an important mode of transport within MaaS, as the car still will continue to be part of an efficient and flexible mobility system. It is also seen as one of the major challenges in a MaaS system because it is a mode of transport that requires a change in the users' mobility behavior.

Due to the current mobility situation, the city of Aarhus and its surrounding communities are building a functioning MaaS ecosystem for collective transport to reduce pollution and CO2 emissions, solve congestion problems in the region and increase the occupancy rate of private vehicles. In 2018, they launched the first phase of the MaaS project to develop a demonstration area for mobility services and mobility service providers. The aim is to analyze and develop an innovative solution for a multimodal data platform that supports both public and private transport operators. Another part is the development of a test pilot for a MaaS service. As MaaS enabler within the project, Fluidtime has provide the city of Aarhus with its MaaS platform technology to facilitate and accelerate the implementation of the new MaaS offering.

As a first step, a mobility solution with an integrated planning platform and private peer-to-peer ridesharing was established that offers either better mobility at the same price or less for society and travelers. The mobility alternatives of Aarhus' new MaaS solution will minimize the number of single occupied vehicles and congestion. At the same time, the expanded service offering will help travelers change their mobility behavior over the long term. After a test phase in spring 2018, the web client visible in Figure 5.10 with integrated public and private transport companies was launched the following summer.

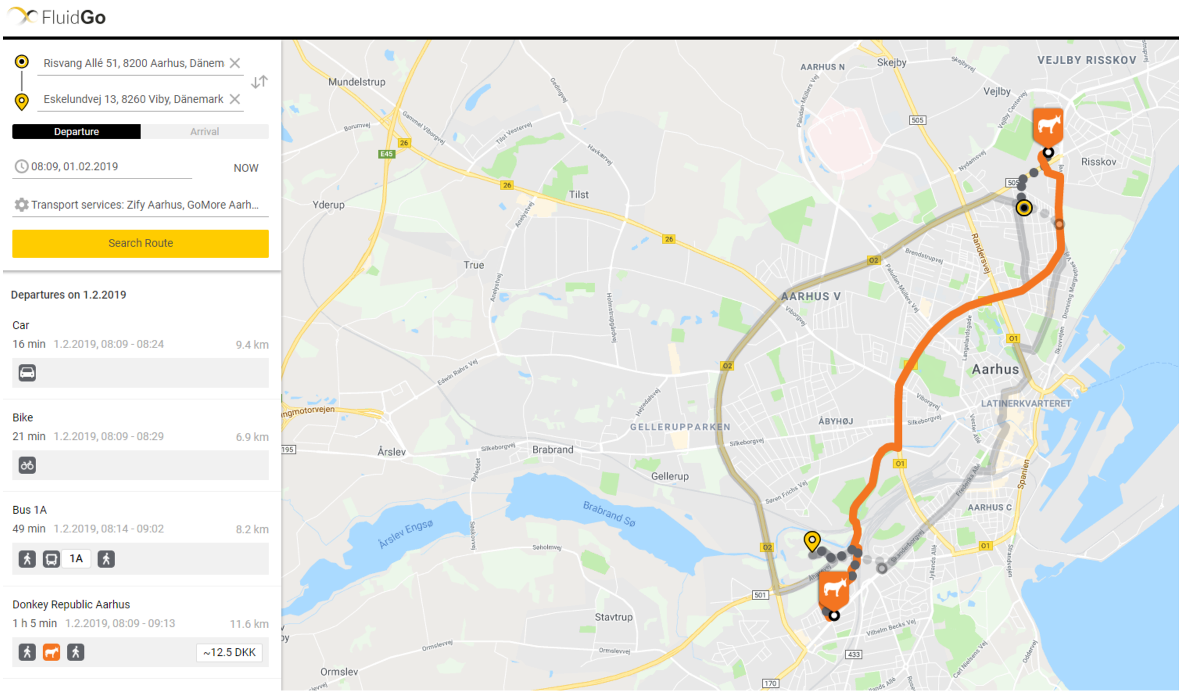

Figure 5.10 Web client of Aarhus' mobility platform (Fluidtime, 2019)

The web client of Aarhus' new mobility platform shows Denmark's public transport Midtrafik, the carpooling service GoMore, the bikesharing service Donkey Republic as well as the carpooling service Zify in one interface. Users can plan their route from A to B, choose between different route recommendations that include all integrated transport service options, and book the desired option via the web client.

The smart MaaS platform enables innovation between public and private actors to facilitate new MaaS providers' access to the mobility market and enrich citizens' lives. To do so, the MaaS enabler ensures that the mobility platform's data is easily accessible to other transport services if they meet the requirements set by the city. In the near future, it is planned that the Danish Automobile Association (FDM), as a mobility service provider, will extend the MaaS ecosystem and open access to services to an even larger target group.

5.7 Recommendations

Starting with MaaS can be a major challenge for many cities or regions due to different information and technology standards of local transport services, but also depending on who takes on the role of the MaaS operator: the city itself, the regional urban subsidized transport company or individual transport providers. In addition, transport regulations may delay the introduction of MaaS at the urban level.

Working with a MaaS enabler can simplify or accelerate certain steps that need to be taken on the road to MaaS for both public authorities and MaaS providers. By implementing a city-wide mobility platform supported by a MaaS platform technology, cities can leverage the fragmentation within the mobility market to their own advantage by defining traffic policies and strategies for different modes of transport to penetrate metropolitan areas and also keep certain vehicle types out of them. Such a platform alleviates the difficulties associated with the fragmentation of the transport market. By storing all traffic-relevant data in one place, cities can perform detailed analyses of the supply and provision of transport compared to demand. As a well-informed actor, they are empowered in their role as Regulatory Service

Providers and receive from their smart MaaS platform the intelligence they need for their management and orchestration role. A platform technology enables MaaS providers to build their mobility platform in such a way that all the important components, from simple integration and data management to equipping the front-end solution, fit together perfectly. The prerequisite for MaaS solutions is always technically given so that only the necessary user group is needed who is ready to use them for their daily travels.

Chapter 6.
Revenue allocation challenge (Prof. Athena Rouboutsos, together with Amalia Polydoropoulou, Ioanna Pagoni and Athena Tsirimpa)

6.1 Introduction

Mobility as a Service (MaaS) is an emerging mobility concept, which has started to gain pace in several cities around the world. Helsinki, Birmingham, Antwerp, Hannover are some of the cities where MaaS initiatives have been implemented in recent years. Although several researchers have debated what MaaS is or is not, current literature has not concluded on a unique definition for MaaS. The majority of definitions capture the conceptual idea of delivering integrated mobility to enable end-to-end trips by offering services combining different transport modes offered by different transport service providers under the umbrella of a single platform and a single service provider for trip planning, scheduling, ticketing and payment.

The first comprehensive definition of MaaS is offered by Hietanen (2014), where MaaS was described as “a mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider”. A later definition for MaaS has been given by Kamargianni and Matyas (2017) and MaaSLab (2018) as “a user-centric, intelligent mobility management and distribution system, in which an integrator brings together offerings of multiple mobility service providers and provides end-users access to them through a digital interface, allowing them to seamlessly plan and pay for mobility”. Other definitions focus on the importance of customization and user-centric features of MaaS (Jittrapirom et al., 2017; König et al., 2016), while other scholars envision MaaS as an opportunity to deliver a more sustainable transport system by the reduction of private car usage and the use of electric vehicles (Gould et al., 2015; König et al., 2016). This paper adopts a broad definition of MaaS as a mobility service which offers flexible, personalized and on-demand mobility by bundling services offered by public and private transport providers (bus, train, tram, metro, sharing schemes, car, taxi, airplane, ship, etc.) and infrastructure providers (parking spaces, ports, airports, etc.) under a single platform for booking, ticketing, payment and planning to cover all trip types (urban, suburban, interurban, cross-border, etc) leading to an integrated mobility system.

Since MaaS is an emerging phenomenon, the analysis of real-life demonstrations is still limited and, thus, evidence on the potential benefits of MaaS implementation is missing. However, there is a growing amount of literature which documents that MaaS is a promising mobility concept and it is expected to deliver several economic, societal, transport-related and environmental benefits. Hietanen (2014) recognise three categories of stakeholders to be benefited by MaaS, namely end users, the public sector and businesses. End users will be offered seamless, easy-accessed, high-quality and value-for-money mobility. Regarding the public sector, MaaS benefits are related to the creation of new jobs, the efficient allocation of resources and the enhancement of transport system reliability. Finally, businesses might benefit from their entrance to new profitable markets for new transport services, while active transport operators might reduce costs of individual operations. Environmental as well as societal benefits are foreseen by Polis (2017), if MaaS is designed in the right way. In addition, if both public and private transport providers join a MaaS scheme, then there is potential to provide customised mobility options and better accessibility to people with disabilities or reduced mobility. Finally, reduced dependence on private vehicles has been documented as a potential benefit of MaaS (Cole, 2018).

To deliver MaaS and take advantage of the above opportunities, viable business models need to be designed, ensuring that the cooperation of multiple actors under a unique mobility platform is succeeded. Stakeholders wishing to lead or join a MaaS scheme and influence how the MaaS operator creates and captures value form the MaaS business ecosystem (Kamargianni and Matyas, 2017; Polydoropoulou et al., 2018). Public authorities, public and private transport operators, data providers, IT companies, ticketing and payment service providers, telecommunications and financing companies are some of the stakeholders that belong to the MaaS ecosystem (Kamargianni and Matyas, 2017; König et al., 2016; Transport Systems Catapult, 2016). Polydoropoulou et al. (under review), who examined the importance of several stakeholders in the deployment of MaaS in three European regions, concluded that the mobility service providers tend to be regarded as the most important actors in MaaS; especially the public transport operators (i.e. bus, metro, tram, rail). However, mobility service providers operate in a competitive environment. In a MaaS scheme, they need to cooperate in sharing information, developing packages that customers are willing to pay for (Mulley and Kronsell, in press; Ho et al., 2018) and, finally, sharing the risks, costs and revenues of the MaaS operation. The costs and benefits of the MaaS coopetition strategy will, ultimately, be compared with their business-as-usual (BAU) scenario supporting or not their entry decision.

Revenues will depend on the MaaS value proposition, i.e. the extent to which integrated mobility is realized within a given scheme. User willingness to pay depends on the attractiveness of the offered services compared to the existing ones. For example, the level of integration already existing in the urban transit system (UTS) and, also, the availability of more personalized or shared mobility schemes such as bike and car sharing available under the MaaS scheme are important factors in the uptake of MaaS. Notably, MaaS is able to endorse the variety of new on-demand transportation services that have appeared in the transportation arena.

Hence, on the one hand, higher revenues are expected when all mobility service providers are included in the MaaS scheme, while mobility service providers and other MaaS service stakeholders will only participate if the revenues allocated to them exceed their BAU scenario. “Participation”, however, may take on many forms, which reflects the risk a particular stakeholder is willing to take. Risk appetite reflects on anticipated returns. The revenue allocation challenge is, therefore, also related to the governance schemes adopted.

6.2. Risks, Costs and Benefits

6.2.1 Understanding the MaaS Innovation

Mobility as a Service (MaaS) bears the characteristics of an innovation that could be disruptive, as defined by Christensen et al. (1997, 2015), or destructive, as defined by Schumpeter (1942/ 2010). More specifically, MaaS could develop addressing a niche market (disruptive innovation) or produce a radical change of the mobility concept (modus operandi – creative destruction) depending on the existing urban mobility market and user characteristics.

As described in the introduction, the key value proposed by MaaS is the integration of mobility services by providing seamless trip planning and one-stop fare purchase for the user.

Should the UTS be characterized by a high level of integration (fare, schedule, information etc.), then MaaS might have little added value, if at all, for the UTS user within this system. It does, however, provide an alternative to the non-UTS user, who might prefer to exchange the private car with other personalized mobility schemes within the city limits or the UTS user addressing gaps in the UTS through personalized mobility schemes. In this case, MaaS could represent a disruptive innovation taking advantage of a niche in the market (Christensen et al., 1997). Of course, a highly integrated UTS is the outcome of a highly regulated urban transit market.

On the other end of the spectrum, a highly deregulated market faces issues of transport integration. In this case, MaaS allows users to fully appreciate urban transit services and, also, potentially exploit more personalized mobility options. Younger generations, environmentally sensitive users, and people who choose to live in cities rather than the traditionally suburban areas are expected to combine public transit with the many new transport service provisions that have entered the market, such as bicycle sharing, car sharing and ride sharing. There are studies predicting a favourable evolution in this direction, particularly in high income countries (Gao et al.,2016). The millennial generation appears to have a different cultural view of personal car ownership and increased use of virtual media (on-line shopping, social media) (Mulley, 2017; Klein and Smart, 2017). Owning a car might no longer be a “must have” lifestyle choice. In this case, a creative destruction is anticipated as the traditional modus operandi is expected to be replaced by a totally different one. Experts agree that the younger generations will be the early adopters of the MaaS innovation (Jittrapirom et al, 2018).

The above line of thinking suggests a continuum between a fully regulated and fully deregulated urban transit system. In fact, regulatory reform of urban public transport has been a major world trend, due to concerns about the economic performance of public transport. Escalating government public transport subsidies have driven many governments to explore private operation or involvement in the management of urban transit systems (Currie, 2016). However, while these reforms have not always resulted in the anticipated economic savings, in some countries they resulted in more fragmented transport operations (O'Sullivan and Patel, 2004; Van de Veldeand and Wallis, 2013) requiring state/public authority interventions. Therefore, even in highly deregulated public transport environments, the public regulator is still present (Currie et al., 2018). Furthermore, there is considerable evidence (Standing et al., 2018) that (over)-regulation is a key barrier in the development of shared transportation services or the introduction of the “Fifth Mode” as MaaS was initially described (Schade et al., 2014).

Hence, formal institutions and regulation will define both the governance and the business model of MaaS in the various cities/locations, as well as the innovation type (disruptive vs destructive) and its potential evolution. At both ends of the spectrum, the opportunity exists for a private actor, especially as platform operators stand to gain the most (Dredge and Gyimóthy, 2015) and MaaS activities rest outside transport operators’ core business.

Table 6.1, shows schematically the potential setup of urban transit mobility (UTM); the potential business models that might emerge based on potential partnership; the economic scope of the partnerships and, finally, the innovation type disruptive or destructive that prevails.

Table 6.1: Schematic representation of potential governance models and MaaS initiatives

Fully deregulated	←	**Urban Transit Mobility**	→	**Fully regulated**
		Shared/On-demand Mobility Schemes		

Potential Business Model Partnerships	On-demand mobility Broker	Trip Planner	PPP[2] of UTS operators & On-demand mobility service providers	"Alliance" UTS & On-demand mobility service providers	Partnership of On-demand mobility service providers	On-demand mobility Broker
Scope	Return on investment	Return on investment	Economic Viability	Social Welfare	Return on investment	Return on investment
Innovation Type	Disruptive commercial innovation	Destructive commercial innovation	Destructive commercial innovation	Destructive Policy innovation	Disruptive commercial innovation	Disruptive commercial innovation

Notably, a "broker" at both extremes is the MaaS platform operator. In the one extreme, the broker operates the on-demand services only; on the other, public transit operators might be included. The latter, instead of just opening information channels, might extend to the creation of an alliance. An alliance can also be formed amongst on-demand service providers. In these cases, returns on investment are anticipated, while the "on-demand mobility broker" is the case with the most fitting "disruptive innovation" profile.

What is of interest, however, is the potential of a "alliance" initiated by the public transport authority. Here, the emphasis is on policy intervention and sets MaaS as a policy initiative rather than a commercial innovation. Moreover, innovation that might bring disruptive changes to urban mobility "needs to be managed or orchestrated rather than simply left to market forces" (Wells and Nieuwenhuis, 2012). Highly regulated urban transport systems have the possibility to address this challenge. However, in this case, the scope is social welfare, and, in this context, the service might be subsidized.

Furthermore, it should be noted that contributing or joining MaaS requires transport operator/provider excess capacity and operational efficiency (Roumboutsos et al., under review). Both might be found in on-demand mobility schemes and private operation of public transport. Especially the latter, found mostly in advanced economies are often characterised by high quality services and low ridership (Currie, 2016) as opposed to emerging or ex-transition economies where public transport shows high ridership and great needs for investments. From this perspective, it would seem that involving PT operators are more likely to appear in more advanced economies, even though MaaS can also be considered as an extension to the existing PT network.

6.2.2 Emerging governance models, assumed risks and the revenue challenge

Figure 6.1 maps the potential business partnerships and their scope. It also, suggests governance models and respectively assumed risk by the business champion/leader and the other "participants". More specifically, participation in a MaaS scheme may take on various forms resulting in respective risk taking by the MaaS operator and the participants.

In "Alliance", mobility service providers formulate a loose partnership in support and promoting each others services. Each mobility provider remains a fully independent entity and assumes minimum, if any, risk.

More complexity is found when the governance model is characterized by a "broker" or is described by a "partnership". When considering the MaaS Champion/Leader, usually described as the MaaS operator, there are two possible roles to be undertaken: MaaS "broker" or MaaS "coordinator".

[2] PPP: Public-Private Partnership

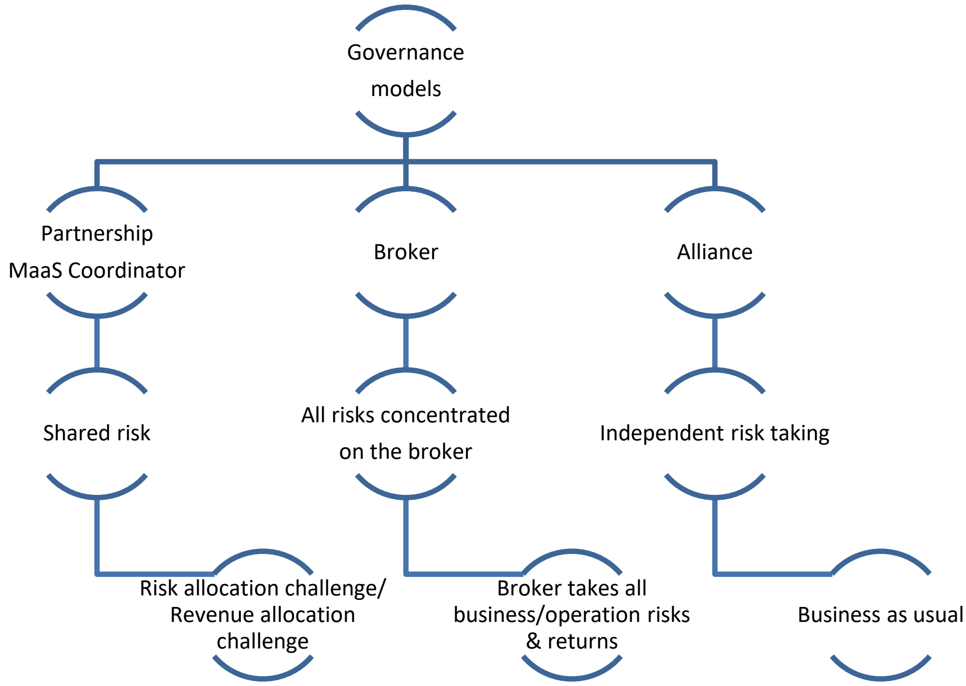

Figure 6.1: Potential governance models and respective risk uptake

6.2.2.1 *The MaaS "broker"*

As a MaaS Broker, the MaaS operator undertakes the full risk of the activities while all other stakeholders involved provide services to the broker creating bilateral "buyer-seller" (principal-agent) relations. The broker assumes the entire business risk and enjoys all profits. Depending on the Broker's risk appetite (or assessment of the mobility opportunities), the implemented business model may range from the provision of travel/trip planning services to the realizing the full potential of MaaS.

The level of payment options is representative of the complexity of the governance model and the level of risk undertaken by the Broker, while mobility service providers assume minimum risk and have no stake in the endeavour (see Figure 6.2).

		Broker		Mobility Provider	
		Benefits	Risks	Benefits	Risks
Level 5 Subscription-based billing & Payment	• Mobility Packages • Subscriptions	• User Profile • Portfolio of risks	High	• Pre-sale of availability	Low
Level 4 Account-based Billing & Payment	• Monthly invoicing	• User Profile • Crowdsourcing of mobility data	Medium	• Reduction in sales costs	Low
Level 3 Pay-as-you-go	• Invoicing	• User Profile • Crowdsourcing of mobility data	Medium	• New sales outlet	None
Level 2 Direct payment	• Booking • Direct Payment	• User Profile • Crowdsourcing of mobility data	Low	• New sales outlet	None

Level 1 Information	• Schedules • Routing		Low		None

Figure 6.2 Benefits and Risks Levels for the Broker and the Mobility Providers under payment options

In all cases, the broker establishes with each mobility service provider a bilateral agreement. The content of the agreement ranges from providing schedules, booking and ticketing to describing the arrangement for the data exchange/interface compatibility and provision of availability as well as the related fare pricing formulae. However, in all cases mobility service providers continue to operate independently in the mobility market.

The broker may negotiate the price, for example, based on availability bought, which in any case would need to be below market prices offered. Greater price reductions are expected in situations where the seller (agent) has excess capacity. Negotiated reduced mobility service prices might be passed on to the customer and/or used to cover broker operating costs and respective profits. The broker would then undertake losses in full. The model becomes viable when including most, if not all mobility providers and offering subscription packages, which could balance the broker's, risk portfolio. Hence, the revenue issue is addressed as in the case of the Mobile Communications Sector.

6.2.2.2 *Partnerships and the MaaS "coordinator"*

As MaaS "coordinator", the MaaS operator coordinates the activities of partners, who form partnership. Operating costs are assigned to the legal entity representing the "partnership" and revenues are allocated to partners. The "partnership" requires multilateral agreements, interoperability and faces the challenge of revenue allocation. "Partnerships" strive on their ability to provide multiple mobility options leading, when considering revenues, to the "museum pass problem". Notably, the complexity involved in delivering a service that spans multiple modes of transportation, with multiple providers, for a single fare is not straightforward, as each mode needs to be appropriately compensated[3]. Notably, in this case the coordinator and the mobility service providers share the same risks (see Figure 3). Equally so, benefits for the mobility providers exist when Level 5 payment option is included in the MaaS offer.

Finally, under this governance model, Public-Private-Partnerships might emerge as public mobility providers might be directly included in the partnership.

		Coordinator & Mobility Providers		
		Costs	Benefits	Risks
Level 5 Subscription-based billing & Payment	• Mobility Packages • Subscriptions	• Coordination • Sharing of information • Revenue allocation challenge	• Reduction in sales costs • New markets	High
Level 4 Account-based Billing & Payment	• Monthly invoicing	• Coordination • Sharing of information	• Reduction in sales costs • New markets	Medium
Level 3	• Invoicing	• Coordination	• New sales outlet	Medium

[3] Of course, a "pay-as-you-go" option might also be available, which works like most route planner apps: A trip can be organized as a single trip chain, but the user would then pay separately for each leg.

Pay-as-you-go		• Sharing of information		
Level 2 Direct payment	• Booking • Direct Payment	• Coordination	• New sales outlet	Low
Level 1 Information	• Schedules • Routing			None

Figure 6.3 Benefits and Risks Levels for the Coordinator and the Mobility Providers under payment options

6.3 Reflection on Current Practice

MaaS is a novel concept and, as such, many efforts are underway following different business models and navigating through institutional systems which are not always supportive or favorable (see Polydoropoulou et al., 2019 under review).

Table 6.2 lists 13 MaaS applications. Amongst them, only two (Whim and UbiGo) offer a MaaS scheme reflecting the full notion of mobility as a service including a considerable range of transport modes and Level 5 payment options. Whim constitutes a "broker" governance model and may be described as an investment project. It includes most mobility modes (public and private) and three payment options: pay-as-you-go; a monthly subscription with limited use of on-demand services and an annual subscription with unlimited usage of on-demand services. As a "broker" model, all risks are concentrated on the broker, consequently on the investors, as due losses and profits. UbiGo is a spin-off financed by Vinnova. The Gothenburg application, despite meeting project expectations (increased transport options, easier payment, tracking expenditures, and reduced need for private car ownership) folded with the completion of the project. The effort was confronted with low revenues due to less than expected car rental and car sharing services demand and the cost of purchasing public transport services as regulation prevented the reselling of PT services at reduced cost. Furthermore, tThe introduction of a registration fee or a minimum amount in advance was not well received by the users (Jittrapirom et al, 2017).

Table 6.2 Current MaaS initiatives

MaaS Schemes	Coverage Area	In Operation Y/N	MaaS Operator Type	Urban Public	Bike Sharing	Car Sharing	Car Rental	Taxi	Rail	Parking	Flights	Coach	Governance Model	Revenue Allocation
STIB+ Cambio	Brussels	Y	PU	X	X	x		x	x	x			Alliance	Not required. Independent service.
Qixxit	Germany	Y	PR						x		x	X	Broker/ Level 2	Not required
Moovel	Germany	Y	PR			x	X	x	x				Broker / Level 2	Not required
Switchh	Hamburg	Y	PR		X	x							Partnership /	Not required

													Level 2	
Hannove-rmobil	Hannover	Y	PU			x		x	x				Partnership / Level 2	Not required
Mobility Mixx	Nether-lands	Y	PR	X	X	x	X	x	x	x			Broker / Level 2 & 3	Not required
NS-Business Card	Nether-lands	Y	PR	X	X	x	X	x	x	x			Broker / Level 3	Not required
Radiuz Total Mobility	Nether-lands	Y	PR	X	X	x	X	x	x				Broker / Level 3	Not required
TransitApp	US, Canada, Europe, Australia	Y	PR	X	x	x		x					Broker/ Level 1	Not required
Tuup	Finland (Turku region)	Y	PR	X	x	x	X	x		x			Broker/ Level 1 & 2	Not required
Whim	Helsinki, Birmingha m, Antwerp	Y	PR	X	x	x	X	x	x				Broker/ Level 3 & 5	Not required
SHIFT	Las Vegas	N	PR		x	x	X						Broker Level 3 & 5	Not required
UbiGo	Gothen-burg	N	PR	X	x	x	X						Partnership / Level 5	Pilot project with public support

From an environmental point of view, MaaS is expected to provide respective benefits by supporting the use of e-vehicles. SHIFT was an ambitious investment project (Project 100) in Las Vegas planning to combine Uber and autonomous vehicles (had placed an order for 100 Tesla vehicles) closed down considering the investment that still needed to be placed before the project could take-off . Moovel, in Germany, is a partnership between Daimler AG and the BMW Group providing in combination three applications: Carsharing, taxi-hailing, and rail,.a. Along with a trip planner application. Their key scope isfif to promote e-vehicle usage. However, the payment option they offer is low (Level 2) by which they avoid the revenue allocation challenge. Hannovermobil, funded by the public, is also an application in support of e-mobility reverting to separate bookings.

Of the remaining applications listed: one is purely a trip planning app (TransitApp) and six (Qixxit, Switchh, Mobility Mixx, NS-Business Card, Radiuz Total Mobility, Tuup) address different target users providing respective flexibility but with payment options that are either based on pay-as-you-go (or charge-as-you-go) schemes or redirecting to separate bookings. Again, these are low risk applications of MaaS avoiding the revenue/demand risk and setup as broker schemes.

Finally, interesting is the case of the alliance between between STIB (PT and Rail operator) and Cambio (and also other ride-sharing, bike-sharing and park & ride services). The scope of the alliance is to extend STIB services and network using on-demand services. The scheme consists of promoting each other's services and positive results (increase in PT ridership, decrease in car usage, etc.) have been reported. However, each partner in the alliance, despite promotions on own services offered in favour of the other partners, continues to receive separate revenues from usage.

The reflection on the current practice suggests that the emphasis of current efforts is on setting up the applications, maneuvering regulatory and other institutional issues and addressing revenues through minimum profit configurations, which are not sustainable in the long-run.

A final point of interest is that in the United States most applications are orchestrated by the private sector (Pöllänen, 2018; Buehler and Pucher, 2012) and emerging mobility service providers are more likely to be the champions of MaaS (House, 2018). However, Polydoropoulou et al. 2019 (under review) identified that MaaS ecosystem stakeholders expect a leading role by public transport authorities in Europe. This is considered critical by relevant actors for a successful deployment of MaaS.

6.4 Reflection on Other Sectors

Bundling of services and products has been used for decades in various industries (e.g. finance, hospitality, health care, telecommunication, museums), as a measure for stimulating demand and achieving cost economies for the parties involved (Guiltinan, 1987; Cataldo and Ferrer, 2017; Fanga et al., 2017). At an early stage, companies focused on tie-in sales of their products/services (pure bundling), while gradually it was apparent that mixed bundling strategies can be more effective especially in cases where competition exists (Guiltinan, 1987; Venkatesh and Mahajan,1996). In many industries, bundling is applied by one company which offers a set of its products or services as one combined product or service package. A typical example comes from the telecommunication sector, where companies offer “double” or “triple” play packages that typically include landline telephony, Internet, digital/satellite television), while mobile phone providers offer bundles which include phone calls (minutes), text messaging and internet access/data (Klein and Jakopin, 2014).

However, in several industries bundling is not restrained to the combination of products/services of a single company, but different entities bundle their services and offer a package to potential customers. For example, online travel aggregators such as Expedia offer vacation packages which include various combinations of services from different companies (i.e. hotel rooms, car rentals, air tickets). Similarly, museums around the world have created passes (i.e Paris Museum Pass, Berlin Museum Pass) providing access to their facilities, for a pre-specified period of time on a discounted price. What is challenging in this case is the way revenues are distributed among the different product/service providers.

In the case of Museum passes, Ginsburgh and Zang (2003) proposed the use of the Shapley value (Sharpley, 1953), where the revenues generated by each pass holder, are equally distributed between the museums (service providers) that the pass holder has visited. This approach can be further expanded by taking into consideration the relative “power” that each service provider brings to the pass package by taking into account various factors, such as museum reputation, importance of collection, etc. However, Fernandez, Borm and Hamers (2004) questioned the suitability of the above approach on the basis that it does not take into consideration the asymmetries that may exist in terms of regular tickets prices and the number of visits a pass holder may conduct, and thus proposed the application of a bankruptcy model. The later approach also reflects on the various “rules” that need to be agreed on when addressing revenue allocation in such cases.

Hence, similar problems have been addressed in other sectors, especially the communication sector and the current personal communication market, which has inspired the MaaS subscription model (Goodall et al., 2017; Li and Voege, 2017). Also, airline alliances address a similar problem, while the most prominent problem where user value is based on the number of available options, is the revenue allocation problem of the “museum pass”.

6.5 The Revenue Allocation Challenge

The revenue allocation challenge is profoundly related to the Revenue Challenge. As a new innovation concept, MaaS is primarily faced with the issues of deployment and market uptake. It is faced with initiation costs and the complexity of coordination, governance and the subsequent agreements between partners; all within the uncertainty of users' willingness-to-pay for services.

The overview of current applications reflects the aforementioned uncertainty, which is addressed through very conservative approach to the implementation of the MaaS concept. This approach is neither supportive of a disruptive nor destructive innovation.

In order to address the uncertainty, key factors are discussed in this section. As every effort in support of transport integration, MaaS is also faced with three potential outcomes:

- Synergy, when the result is greater than the individual outcomes before the effort;
- Additivity, when the result is equal to the individual outcomes before the effort; and
- Substitutability, when the result is less than the individual outcomes before the effort.

6.5.1 Demand

6.5.1.1 The risk of additivity

There is significant uncertainty with respect to demand for MaaS services and offers. However, the demand for each individual modality offer is known to the respective operators. The fact that seamless travel might introduce a shift from the use of the private car to on-demand or public transport services is of considerable certainty. Therefore, the key risk operators are faced with is "additivity" as a result of MaaS, expressed as demand shifting from one modality/operator to another. This risk is of particular importance to public transport operators, where modal shift may manifest towards more personalized mobility options such as car-sharing (Le Vine and Adamou, 2014).

6.5.1.2 Attractiveness in the number of options

Mobility users are faced with the multiple mobility options and their respective applications. They need to combine, evaluate and assess information and then carry-out multiple transactions to complete their door-to-door trip. The result is usually to revert to the most comfortable means of transport, i.e. often their own private car. The MaaS offer becomes all the more attractive when all possible modes of transport are includeding in the same platform. Reasonably, Kamargianni et al (2016) propose an index for Mobility integration, which is principally weighted on the number modes/operators included.

However, while users are attracted by the number of available mobility options not all services will be used. The prevailing issue, in this case, is whether these operators will be compensated. Notably, the question is directly relevant for level 5 payment options, it is of equal interest also for lower level payment options.

Researchers of the Museum Pass problem, addressing the above issue, propose a flat rate in addition to revenue allocated according to revenue allocation rules. This approach might apply equally to accommodate the needs of each case either in an "partnership" formation of partners or as a basis for negotiation the pricing of time or tickets if a "broker" is championing the MaaS endeavor.

6.5.2. Revenues

6.5.2.1 Customers

Revenues are, of course, the result of demand, costs and price paid. Related to the payment options, it is evident that Level 1 to 3 payment options (trip planner, separate bookings/payment, pay-as-you-go) do not provide significant viability as they might only achieve a reduction in customer services costs for mobility providers and minimum returns to MaaS operators, through, possibly, site advertisements or other website generated revenues. The risk of additivity is also present even for lower level payment options. Risks increase for higher levelhigher-level payment options, where subscription packages are offered. Pricing packages and identifying a balance between user willingness-to-pay and package cost is not always straightforward. For example, a study undertaken by Ho et al (2018), revealed that half of their survey respondents would take up a MaaS offer but their willingness-to-pay in many cases was below the current market price of services. Also, users are hesitant in pre-paying for services or even a minimum advance (Jittrapirom, 2017).

Consequently, implementing payment options of lower level, allows for user confidence and trust to be built but does eliminate the risks mobility providers are facing nor provides the grounds to create risk portfolios nor increase operational efficiency leading to lower operational costs.

6.5.2.2 Subsidies

Mobility as a Service should extend the “Sustainable” characteristics of a public transport system. Considering social benefits and welfare, public transport is most often subsidized to compensate for low ridership and/or price/fare reductions needed and assumed socially important. In the same context, these subsidies to public transport might extend to public transport within the MaaS offer.

Building on this approach, one questions whether MaaS also contributes to the same sustainability goals as public transport and in this context, if MaaS should be subsidized. In many cases, MaaS applications today constitute funded projects or investment projects (where investors are probably seeking long-term returns). Hence, alternatives to subsidization are already present. However, a more structured approach would benefit the MaaS operational efforts and could, possibly, be related to improved levels of sustainability achieved through an extended “public mobility service”. Currie et al (2018) based on a framework proposed by De Gruyter et al. (2017) provide a methodology and scores for public transport sustainability performance for 88 cities in the world. These are based on indicators reflecting apart from economic, environmental and social sustainability as well as system effectiveness. Subsidies could be attached to agreed upon sustainability goals.

Despite the potential benefits, there is increasing evidence that support through subsidies is not favoured, as in many cases respective regulation is limiting (Jittrapirom, 2017). This translates in the MaaS service buying public transport fares at a price higher than these are sold to the public and the public authorities requesting that private on-demand mobility providers subsidize public transport services.

6.5.3 Seeking the breakeven point

In any cost and returns function capital expenses (CAPEX) and operational/maintenance costs (OPEX) need to be balanced by the revenues. The simple cost and returns function for a MaaS endeavor at the breakeven point might be described as below (Polydoropoulou et al, 2018):

$$CAPEX(t)+OPEX(t)=\sum_n P_n S_n(t)-\sum_m \left[\sum_n C_n R_m(t)\right] \quad (1)$$

Where:

CAPEX is the amortization of the initial investment (capital cost) in year t

OPEX is the operational and maintenance (O&M) costs of the MaaS in year t

Pn and Sn is the nth promotional package and its sales of year t,

Rm are the returns to the mth operator participating in the MaaS offer in year t, and

Cn is the consumption of the Pn package sold. Cn is assumed to follow a normal distribution, which over time and as users become more aware of their usage patterns, the standard deviation will decrease and Cn will tend to 100% consumption.

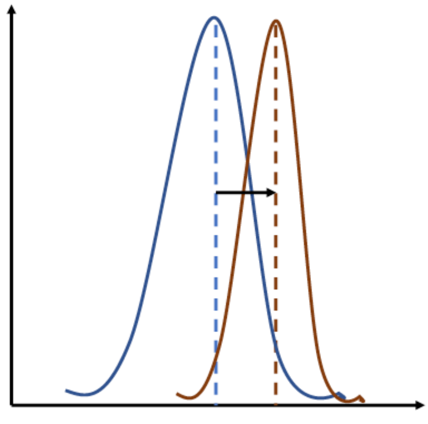

Figure 6.4 Figurative representation of Cn (Polydoropoulou et al., 2018)

6.5.3.1 Breakeven for the Broker

In this configuration, the MaaS operator "buys" availability through bilateral agreements from the other mobility service providers at reduced prices. The reduction offered will be based on:

- Current excess capacity of the provider
- Provider profit margins

The scope of the negotiation would be to reduce the value of the term $\sum_m \sum_n C_n \, R_m(t)$.

Mobility providers with no excess capacity or with marginal profit margins (e.g. Public Transport Operators) will not be able to offer reductions. As noted previously, total risk is allocated to the "broker", who will need to strive on demand (n) in order to break even.

6.5.3.1 Breakeven for the Partnership

In this configuration, the initial breakeven equation places emphasis on the term $\sum_m \sum_n C_n \, R_m(t)$, i.e.

$$\sum_m \sum_n C_n \, R_m(t) = \sum_n P_n \, S_n(t) - CAPEX(t) - OPEX(t)$$

Revenues to be shared result after MaaS CAPEX and OPEX are covered. Once again, there are variants to be considered. Notably, the remaining revenue to be allocated to operators is a function of package underusage (1-Cn) in combination with demand (n). Revenues may then be allocated to mobility providers following the Kalal-Smorodinsky rule or other relevant revenue allocation rule, which also applies in cases of bankruptcy when the value of assets is lesser than the value demanded by creditors.

The above approach may have variants to accommodate for mobility providers, of whom services were present in packages sold but not consumed by the user. In this case, for each package a minimum flat rate could be initially agreed upon per package independent of the services consumed, while the remaining sum is allocated following the overall agreed rule.

In both approaches, in an underdeveloped market where demand for MaaS services is still building up, economic viability is achieved through the under-consumption of subscriptions packages. This is neither sustainable nor fair for the user and could have negative ramifications for MaaS deployment.

6.6. Addressing the revenue allocation challenge

Economic sustainability is a primary goal, also attached to the MaaS concept primary objective: the reduction of private car usage and, potentially, ownership in favor of MaaS. This goal requires time in order to address the key barriers of over-regulation, inconsistent quality of service and the need for recommendation (trust building). It also requires information on the new travel behavioural patterns to be collected so as mobility packages suited to user needs and supporting a profitable portfolio to be structured and, appropriately, promoted. In other words, while the personal communication market as well as other markets might serve as an example in addressing the revenue allocation challenge, their usefulness can only be exploited at a future stage when the MaaS market has matured.

In the meantime, mobility service providers wishing to entry a MaaS endeavor need to assess a number of issues and address them in cooperation with peers competing in the same and for the same market. Figure 6.5 describes the decision points leading the assessment and formulating the MaaS governance, business and revenue allocation model.

6.7 Case studies

[Case studies have been envisaged from the MaaS4EU H2020 funded project. Due to the complexity addressed these are still under way]

6.8. Conclusions and Policy Recommendations

[The Chapter ends with conclusions and policy recommendations.]

Chapter 7.
The infrastructure perspective (Mr. Andrzej Maciejewski)

7.1 Generic services and value proposition of infrastructure providers and operators

Public sector organizations are being increasingly subjected to both legislative and competitive pressures forcing them to reconsider their relationships with users and customers in order to develop a more overt customer orientation (as the primary driver of organizational performance). The creation of value supports the development of a customer orientation, and is a requirement, to which more public sector organizations nowadays adapt. This applies to all sectors of the economy, also to the transportation infrastructure providers.

Expectations of the infrastructure providers’ customers should be considered in wider perspective of governance of the state, which may be defined as “the exercise of economic, political and administrative authority to manage a country's affairs at all levels. It comprises the mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences".

This definition constitutes a sound basis for the responsive and accountable governance which is a key enabler for the Sustainable Development Goals.

According to the United Nations report on Responsive and Accountable Public Governance focusing on satisfying people's expectations in terms of quality, quantity and promptness of the public services delivered within limited resources available is crucial to enhance public sector responsiveness. Achievement of responsive governance depends on how policies, strategies, programs, activities and resources are anchored on people's real needs.

In parallel establishing of strong governance accountability is essential towards delivery of expected goals (i.e. the 2030 Agenda for Sustainable Development Goals). An accountable organizational culture deters waste and mismanagement of resources. Accountability for performance serves to guide, monitor and evaluate public institutions and programs, informing needed improvements. That is why building the capacity for financial and performance accountability builds the trust for leveraging resources and safeguarding funds.

Accountability therefore denotes responsibility for results and outcomes, and not only processes. When operating effectively, it serves to ensure that public governance can flourish, related institutions perform well and services are delivered to citizens effectively and efficiently.

Adaptation of responsiveness and accountability of governance requires to address a number of challenges for the public sector and to re-asses its role in public services delivery, like:

(1) Changes of demographic profiles

(2) Increasing customers' expectations

(3) Awareness of public services' users

(4) Demand for greater transparency

(5) Budgetary constraints

(6) Global competition to attract investments.

Achievement of these requirements for the governance need sound understanding of what public services are and how they may be provided. According to the international best practice, collected in the report of PwC's Public Sector Research Centre[4], delivering of public services may be based upon five key strategic enablers:

(1) Understanding of the customer,

(2) Removing silos between governmental agencies,

(3) Building capacity,

(4) Service delivery,

(5) Continual improvement.

Based on the findings of this study customer focus is often challenged by public sector culture, hierarchical organizational structures and differing public sector priorities, whereas public agencies priorities need to be aligned to customer requirements.

[4] „The road ahead for public service delivery", PwC Public Sector Research Centre

This needs the connected government what means common vision, supported by integrated objectives, outcomes or process flows. Key elements for "connected government" should include – inter alia – common service standards or break down intra-agency silos before starting to break down cross-agency silos.

In terms of capacity building main pillars are defined as long-term planning, organizational and process design, use of technology, support for people for the organization and culture of the organization change.

Moreover, to be able to define the appropriate service delivery model, the overall goals of public service delivery should be clearly articulated in terms of: (a) quality of service, (b) cost of service, (c) suitability of different service delivery channels for different customers segments. That is why the authors of this report recommend as a first step towards developing the right service delivery model to clearly define the role the specific public agency/authority intends to play – i.e. policy maker, regulator or service provider. What has been also found as critical is understanding of how technology may support to achieve the organization's goals, how public-private partnership can deliver targeted outcomes and how to manage the risks.

Finally – in terms of continual improvement – it is recommended to benchmark carried out activities, finding the answers for following three questions: (a) what to innovate (b) where to learn from (c) how to adopt.

Mobility as a Service concept fits to these requirements as it puts customer needs in the center. It offers consumers access to a range of vehicle types and journey possibilities.

From the traditional perspective mobility was provided by management of fleet of vehicles on respective route or network and framed by strategic transport planning objectives. What MaaS changes is exactly putting the customer preferences in the center and framing the mobility system around customer needs.

According to international best practice MaaS value proposition lays in the combination of diversity of transport modes and capabilities to improve travelers' customer experiences (as presented below)[5].

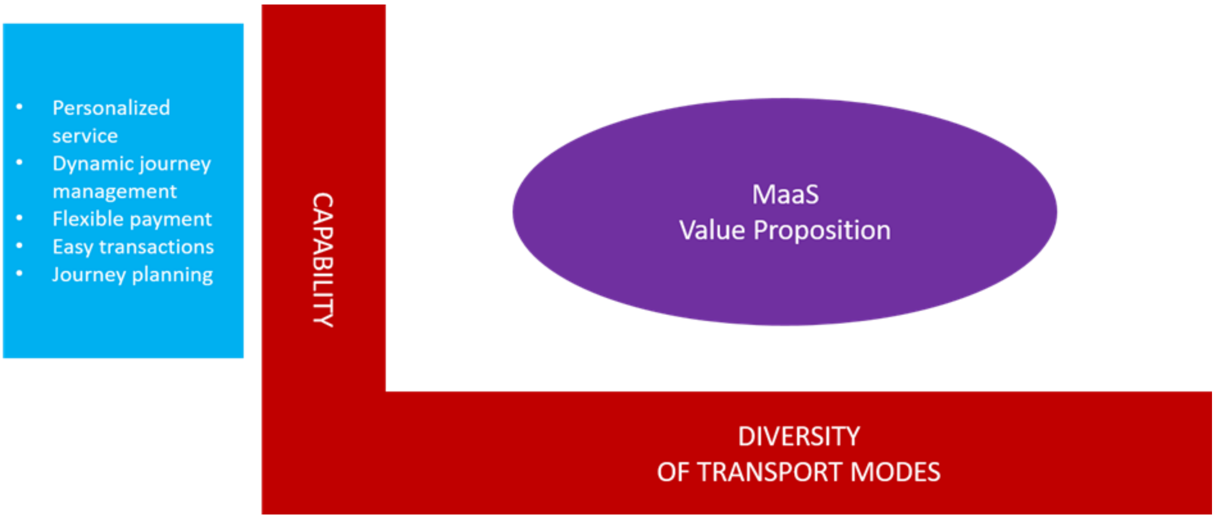

Figure 7.1:

[5] "Mobility as a Service. Exploring the opportunity for MaaS in the UK", Catapult Transport Systems, July 2016

Bearing that in mind the MaaS concept has been defined as "using a digital interface to source and manage the provision of a transport related services which meets the mobility requirements of a customer"[6], thus the possibility to use any form of transport service for any travel need.

The MaaS presents a vast scope of change for stakeholders in the MaaS value chain (as presented below).

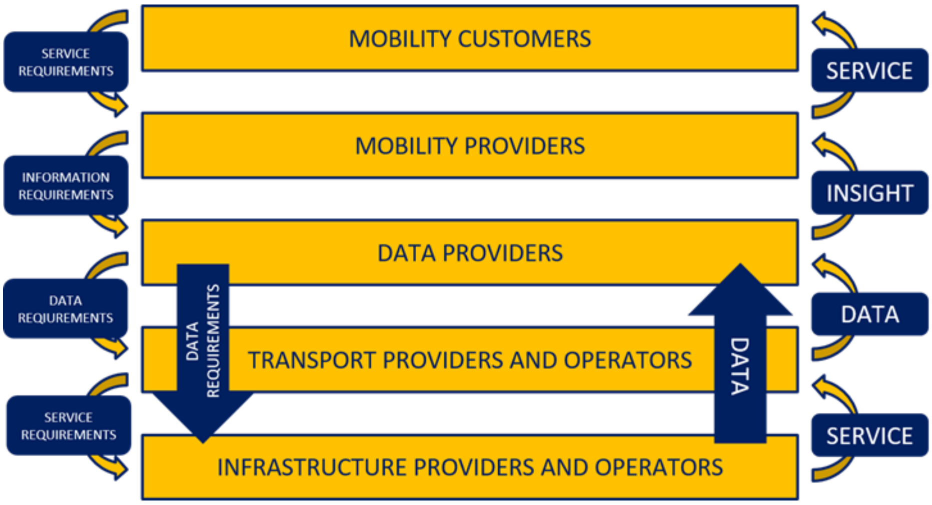

Figure 7.2

It requires moreover appropriate answers from transport and infrastructure operators, hence the infrastructure providers must, in turn, be able to respond to these new needs and expectations in terms of not only MaaS but as well electrification of road transport and intensive development of connected and autonomous driving.

Growing mobility challenges, such as congestion, may be solved by smart mobility solutions such as integrated network management (which includes both traffic management and traffic information measures integrated and managed within a transport network). These changes require new approaches to network management and demand different competences, affecting the balance of tasks that should be retained in-house, as against those that will disappear altogether or which be outsourced or automated. For example, data collection, which now occupies considerable resources of people, equipment and money, will largely be satisfied by crowd sourcing and floating car data together with traditional sources in order to provide adequate and expected quality of information.

Entry of new stakeholders and contractors also requires awareness of which process may be outsourced and when. Lessons learned from the European ITS architecture FRAME have suggested a "no frills" approach, under which authorities should implement the minimum needed, rather than the maximum possible. Service Levels Agreements need to be developed and integrated at operational level to ensure reliability and consistent delivery of services between NRAs and service providers and also for the final customer. This is illustrated by Figure 5 below:

These challenges require an infrastructure provider to be flexible and agile, focused not only on the performing of physical works, but on the managing of effectiveness and efficiency of delivery of a growing number of public services.

[6] Ibid

This means that appropriate activities towards adjusting and/or restructuring of existing business models of infrastructure operators are required.

7.2. Customers' expectations and infrastructure providers value proposition

What is therefore the infrastructure providers' value proposition, what are their customers and service delivery framework and how it will need to be changed to adjust for the requirements of Mobility as a Service?

Typically, i.e. road agencies provide two generic activities: road asset and traffic management.

Asset management includes all activities aimed at restoring or keeping road infrastructure in a desired condition. It delivers services to road users through road infrastructure, and road users access this service by driving on the infrastructure. Hence, we can say that road authorities facilitate the value creation of road users by maintaining, upgrading or renewing the infrastructure. The outcome of this activity is the network with specific condition parameters, which performs services for road users.

Road infrastructure is a resource that road users can make use of and integrate into their value-creation processes. For the users, road infrastructure becomes a means to an end. It does not possess any value per se and only incorporates value propositions.

The extent to which road users perceive value-in-use of road infrastructure then depends on their experience of the road agency's maintenance activities manifested in the experienced road condition parameters. Road infrastructure contributes to the users' value creation by influencing, for example, the time needed to drive, the costs of traveling, and the stress of riding.

Traffic management - the second main activity type of road agencies - denotes all activities that aim at controlling traffic parameters by changing the intended use of road infrastructure. Like road maintenance, it contributes to the value creation of road users by influencing performance parameters of road infrastructure.

However, while road maintenance indirectly provides services through road infrastructure with certain condition parameters, road agencies directly engage with the users through traffic management measures which include the provision of information about the current traffic situation, possible redirection routes in case of traffic jams, and suggestions for appropriate driving behaviour. Since the road agencies adjust their traffic management measures to the current traffic patterns which are to some extent a response to previous measures, road agencies and road users interact with each other; they "take actions of some sort that influence the other party's process"[7].

On that basis the core public service, provided by infrastructure operator may be defined as reliable and safe infrastructure to carry out mobility operations (moving goods and people) by individual users, logistic companies or public and private transportation firms.

Therefore, as we can see, Mobility as a Service does not introduce significant change into infrastructure providers' value proposition, however - as MaaS puts the customer needs in the center, it is based on the new business models and new technologies - it changes other elements of infrastructure providers' business models:

- Customers segments:

[7] Value creation of road infrastructure networks: A structural equation approach, Journal of Traffic and Transportation Engineering, 2016

- Key business processes,
- Key resources,
- Key partners.

7.3 Customer segments

Infrastructure providers are usually the public agencies and/or authorities which use public funding for their investments and operations. The customers segments may be defined therefore as follows

- Citizens
- Tax payers
- Users

As public authorities, infrastructure providers are responsible for the realization of national policy of respective country to answer to the needs and desires of its citizens.

Having most of their funding from public sources (as showed below on the example of UNECE TEM Member Countries[8]) they are responsible for delivering value to those who finance infrastructure providers' activities (tax payers).

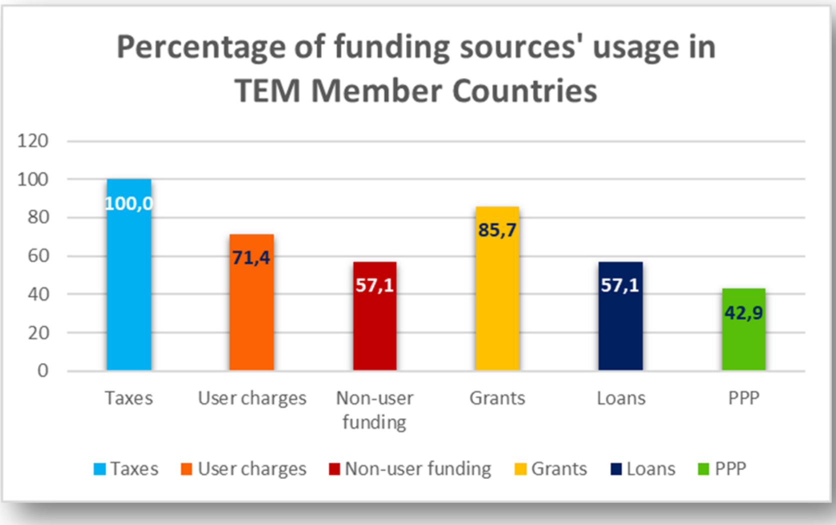

Figure 7.3

Finally, infrastructure providers are responsible for providing of number of public services to their direct clients: infrastructure users. Within this category impact of MaaS seems to be the most visible. Up to know in road sub-sector users could be defined as:

- Drivers
- Logistic/transportation companies
- Cyclist

[8] "Business models for Road Sub-Sector", UNECE Trans European Motorway Project, December 2018

- Pedestrians

Nowadays this group will be enlarged by, for example:

- Mobility service providers
- Mobility customers
- Automated vehicles

This change requires further actions in the service delivery systems of infrastructure providers, thus within their business processes, resources and partners.

7.3 Service delivery framework

According to the International Road Federation the "delivery system"[9] constitutes of:

- The sector governance
  - How decisions are made?
  - How budgets and plans are structured?
  - How incentives are aligned?
  - How roles and responsibilities are divided?
- The collaboration between stakeholders
  - Public sector
  - Private sector
  - Citizens
  - Organizations
- The enabling foundations
  - Capacity and capability
  - Data
  - Accounting principles

The delivery system, tailored in line with this recommendation, requires implementing all of its sections, as they are interrelated. As stated in the report "improvement interventions will only reach their full potential when they are designed and implemented with the full delivery system in mind. The impact of any intervention aimed at increasing the pipeline of planned road projects will be limited if the permitting process is slow and complex due to, for example, poor stakeholders management or collaboration between institutions. Likewise, increased funding for roads will likely lead to increased cost if the supplier market is capacity-constrained and/or oligopolistic in nature".

[9] A better road to the future. Improving the delivery of road infrastructure across the world. McKinsey&Company and International Road Federation, 2018

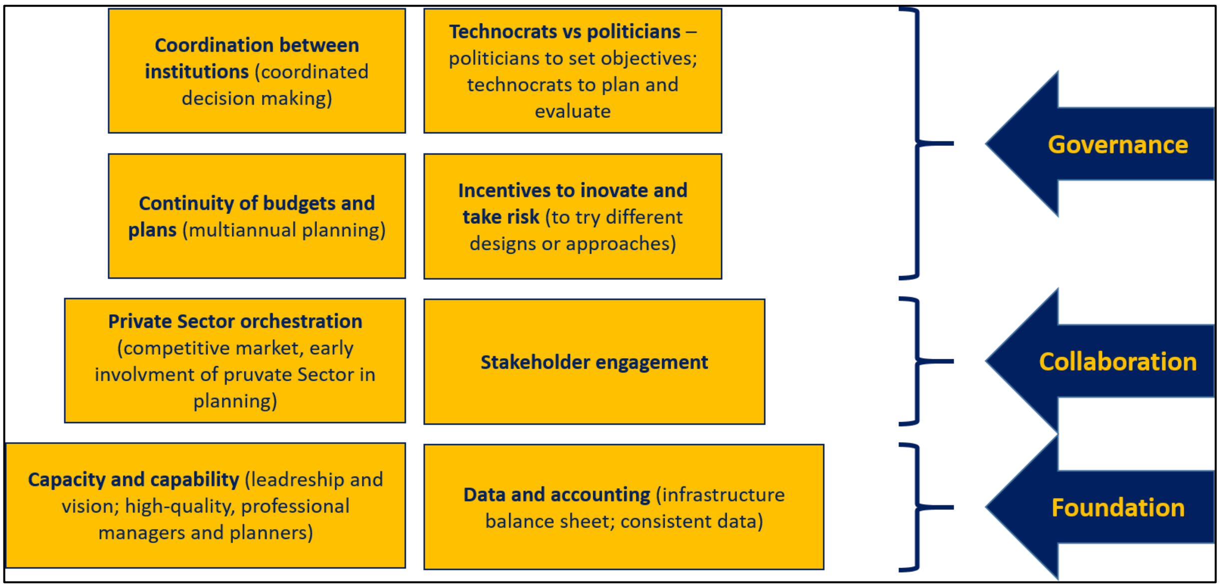

Figure 7.4

The main factors which impede road sub-sector performance may be listed as follows (however not limited to):

- Ineffective project selection and prioritization
- Ineffective construction and supply market due to fragmentation across the value chain
- Oligopolistic supplier industries
- Insufficient planning and design and lack of value assurance processes
- Construction techniques and technology not fully industrialized
- Lack of innovation caused by inertia in design and engineering
- Ineffective procurement processes and contract structures
- Limited use of more advanced procurement, including negotiated tenders
- Limited use of demand management
- Ethics and integrity
- Additional sources of funds
- The future mobility

To capture the full perspective of the delivery system in the road sub-sector, authors of the report propose five-dimensional approach[10]:

Fact-based project selection	Streamlined project delivery	Making the most of existing roads	Governance and capabilities	Funding and finance
Prioritized optimization of infrastructure before new build	Adequate owner team	Demand management	Strong governance and collaboration	Clear strategy for market competition and ownership

[10] Ibid

Fact-based and consistent project evaluation	Well-planned commissioning and ramp up	Increased asset utilization and loss reduction	Robust infrastructure data	Suitable regulation, pricing and value-capture investment
Master planning with coordination across assets/jurisdictions	Rigorous execution and contract management	Robust institutions and processes for combatting corruption	Strong capabilities	Sufficient financial capacity
Strategy linked to socioeconomic objectives	Concept, design and engineering optimization	Total cost of ownership-oriented maintenance	Focus on sustainability	Suitable conditions for private finance
System-wide portfolio prioritization	Effective construction and supply market			Effective approach to PPP
	Effective procurement, tendering and contracting			Strong framework for long-term public funding
	Value-assurance process			Attractive overall investment climate
	Well-defined approach to projects in distress			
	Advanced procurement with synergies captured across projects			
	Seamless permitting and land acquisition			

Table 7.1. Five-dimensional approach for the delivery system.

Implementation of such service delivery framework may be based on the asset management approach.

Asset management – as given in the recent report of UNECE TEM Project[11] - may be considered as an approach or even a business model of the modern road authority, however without appropriate tools, data and training it will remain only an aspiration or ambition of the organization, not the reality expected by customers or stakeholders.

According to the "Guide to Asset Management", published recently by Austroads[12], asset management is not the domain of single department within road authority or even a group of people that works in the field of road maintenance. From the perspective of Austroads it is rather holistic approach for the road organization which responses to both the organization's and customers' needs and which includes decision support systems and business processes.

In Australia asset management business approach was divided into four key concepts which are defined as below:

Key concept	Depiction
The needs of customers	Asset management process must enable the organization to better understand and meet the reasonable expectations of its customers
Whole-of-organization approach	Asset management is a core business activity that involves most of the functions across an organization
A sequence of business processes	Asset management requires complexity and comprehensiveness of business processes
Not a "one size fits all" approach	Having in mind how contexts, governance rules, maturity levels may vary within countries, there is not "one size" asset management solution

[11] "Business models for Road Sub-Sector", UNECE Trans European Motorway Project, December 2018

[12] Guide to Asset Management, Austroads, July 2018

Table 7.2. Features of an asset management business model. Austroads 2018

Presented above approach derives from the legacy of – inter alia – British Institute of Asset Management. This organization strongly underlines that asset management is not just about the assets as such. However modern societies heavily rely on physical assets, managing of these assets should provide products and services – now and into the future. From their perspective assets can be made of anything – i.e. brands, licenses, opportunities – anything what helps an organization to achieve its purposes and objectives[13].

Asset management may be therefore also considered as a meta-level process within an organization which enables extracting value for the customers and for the organization, which requires to adopt holistic approach as successful asset management needs the participation of many individuals within an organization and its supply chain.

To control, coordinate or direct asset management activities, organizations implement asset management systems, which can provide risk control and give assurance that the asset management objectives will be achieved.

An asset management system is therefore a set of interrelated and interacting elements of an organization, whose function is to establish the asset management policy and asset management objectives and – last but not least – the business processes, needed to achieve those objectives. The elements of the asset management system should be understand as a set of tools, including policies, plans, processes, procedures and IT systems.

When establishing its asset management system, an organization should take into consideration its internal and external contexts. The external context includes the social, cultural, economic and physical environments as well as regulatory, financial or other constraints. The internal context includes organizational culture, mission, vision and values of the organization. Stakeholders inputs and expectations are also part of the context of the organization.

Another key element of an asset management system is a strategic asset management plan (SAMP), where the organization defines the principles by which intends to apply asset management to achieve its organizational objectives. The SAMP will give also stewardship for the asset management system in the development of organization’s operational asset management plans. These asset management plans should have specific and measurable objectives (i.e. timeframes and the resources to be used) and should define the activities to be undertaken on assets (how this may be done in the road sub-sector will be presented later in this chapter).

Apart from investigation of the context of the organization and leadership requirements in terms of strategic plan, asset management system consist of:

- Planning;
- Support;
- Operation;
- Performance evaluation;
- Improvement.

To visualize relationships between the elements of an asset management system and its requirements given in the ISO norms, Figure reproduced from the Annex B of ISO 55002:2014 has been provided below.

[13] An Anatomy of Asset Management, The Institute of Asset Management, 2015

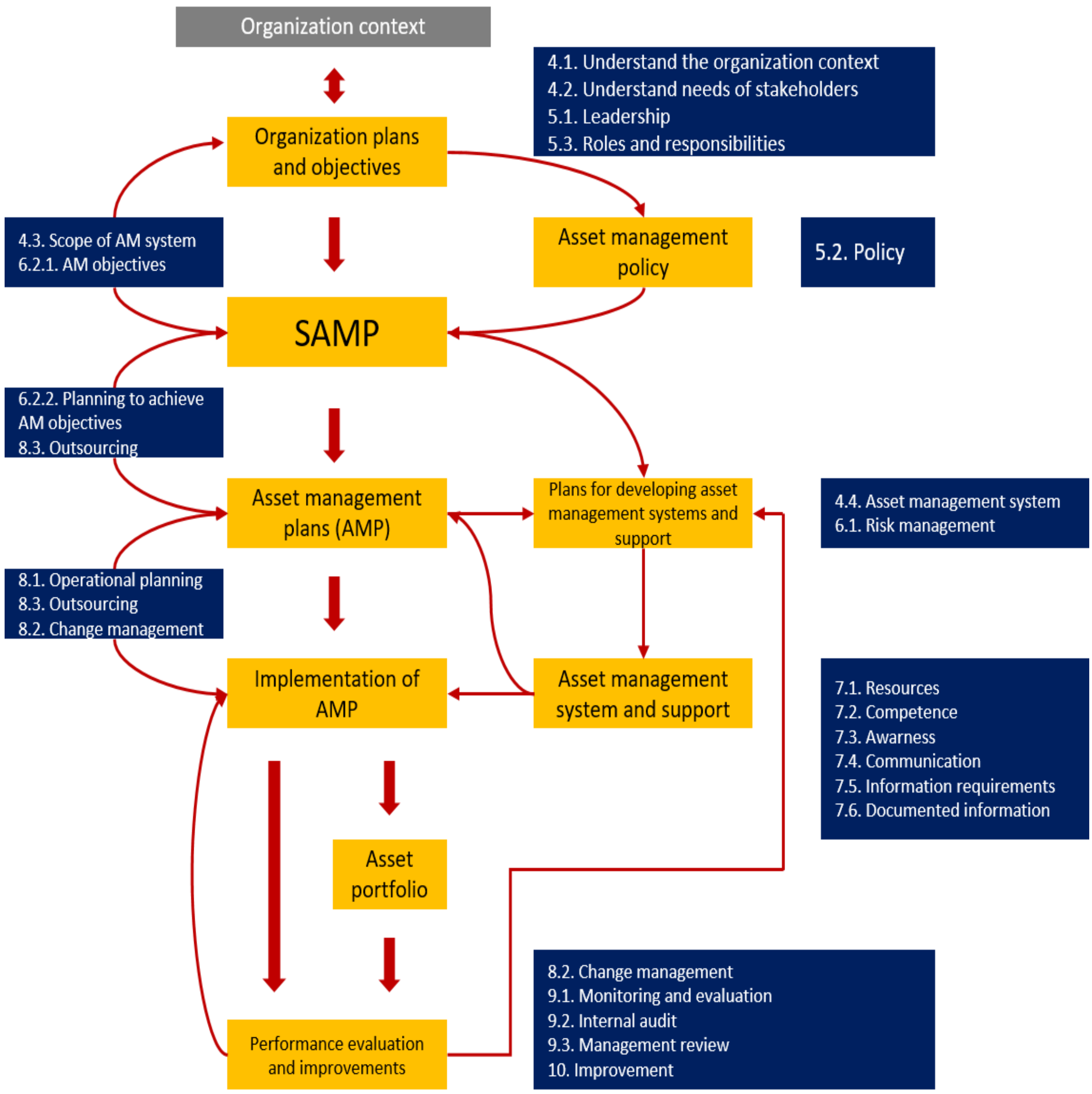

Figure 7.5: Relationship between key elements of an asset management system. ISO 55002:2014

As stated above the Institute of Asset Management provides comprehensive model of asset management system. is provided by Institute of Asset Management[14]. This conceptual model comprises of six Subject Groups covering a total of 39 asset management Subjects. The importance of individual Subject to a specific organization will depend on its organizational purpose and context.

Group 1: Strategy and planning

This group aligns organization's activities and the outcomes from its assets with the overall objectives of the organization. This assists in day-to-day activities through the asset

[14] Ibid

management plan/s. These activities include also planning to improve asset management capabilities and the management system.

The first Group consists of:

a. Asset Management Policy

b. Asset management strategy and objectives

c. Demand analysis

d. Strategic planning

e. Asset management planning

Given above asset management subjects grouped as strategy and planning activities, may be compared to these given in the ISO norm – IAM's Asset Management Policy is ISO's 55002:2014 point 5.2. – Policy. IAM's strategic planning is a process which establish asset management objectives and strategy (as in point "b.") which may be compared to ISO's SAMP. Asset management planning is consistent with mentioned in ISO norm Asset Management Plan, while Demand analysis is the process which organization uses to asses and influence the demand for, and level of service from, an organization's assets (so knowing the context of the organization and stakeholders expectations, as proposed in ISO).

Group 2: Asset Management Decision-Making

This group considers the challenges faced and the approaches to decision-making for the three main stages of an asset's life: (1) acquisition/creation, (2) operation and maintenance, (3) end of life. Decisions made at each stage have an impact on subsequent stages.

The second Group consists of:

a. Capital investment decision-making

b. Operation and maintenance decision-making

c. Lifecycle Value Realization

d. Resourcing strategy

e. Shutdowns and outage strategy

Group 3: Life Cycle Delivery

This group considers the implementation process of the asset management plan/s developed in the first group's set of processes. It foresees control of the activities undertaken to acquire, operate or maintain and dispose the assets as essential for the successful delivery of the asset management plan/s. Focusing on integration of activities across the life cycle enables organizations to reduce avoidable costs through good designs, procurement or O&M practices.

The third Group consists of:

a. Technical Standards and regulations

b. Asset creation

c. Systems engineering (policies and processes for the requirements analysis, design and evaluation of assets)

d. Configuration management (consistency of physical and functional attributes of an assets with its design and operational information through its life)

e. Maintenance delivery

f. Reliability engineering (ensuring that an item shall operate to a defined standard for a defined period of time in a defined environment)

g. Asset operations

h. Resource management

i. Shutdown and outage management

j. Fault and incident response

k. Asset decommissioning and disposal

Group 4: Asset information

This group considers requirements in terms of data and information which an organization should possess to effectively and efficiently manage its assets. Data and information requirements, including quality requirements, need to be identified and defined.

The fourth Group consists of:

a. Asset information strategy

b. Asset information standards

c. Asset information systems

d. Data and information management

Group 5: Organization and people

As implementation of asset management business model is usually an important change for an organization within this group processes like reviews of organizational structures, roles and responsibilities or contractual relationships are taken into consideration. Subjects in this group are highly interdependent and have strong influence on an organization's ability to adopt and embed asset management.

The fifth Group consist of:

a. Procurement and supply chain management

b. Asset management leadership

c. Organizational structure

d. Organizational culture

e. Competence management

Group 6: Risk and review

This subject group contains core activities associated with the identification, understanding and management of risk. Moreover it proposes to establish effective feedback and review mechanisms to provide assurance that objectives are being achieved and to support continual improvement of asset management activities.

The sixth Group consists of:

a. Risk assessment and management

b. Contingency planning and resilience analysis

c. Sustainable development

d. Management of change

e. Asset performance and condition monitoring

f. Asset management system monitoring

g. Management review, audit and assurance

h. Asset costing and valuation

i. Stakeholder engagement

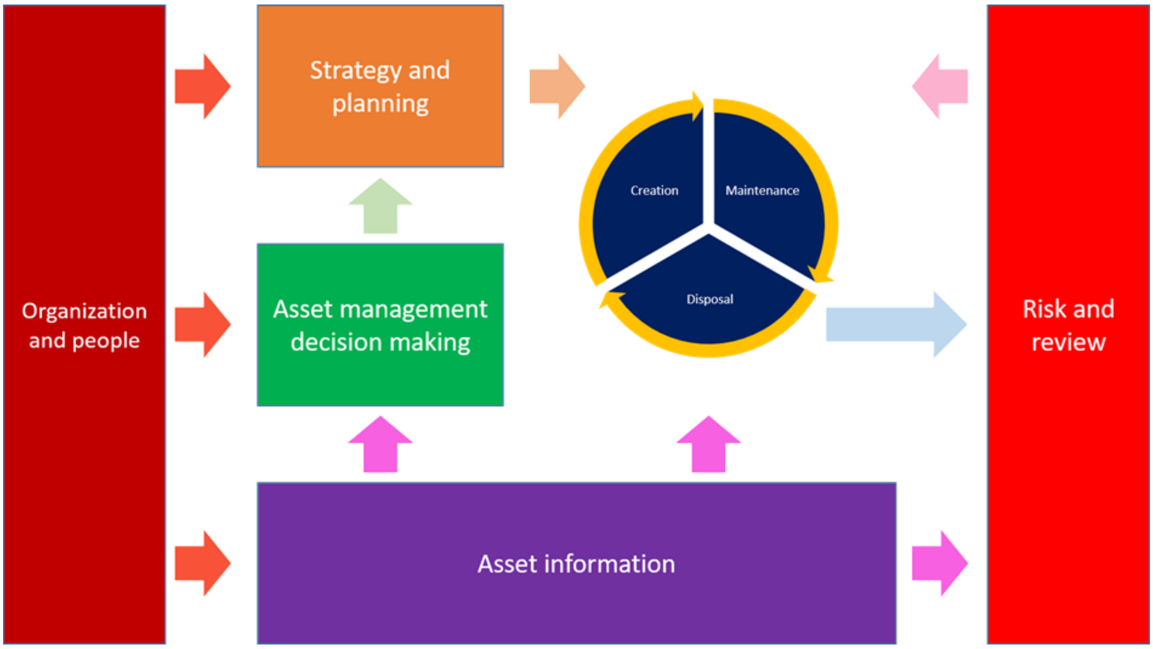

Figure 7.6: The IAM's conceptual asset management model

As asset management system is holistic and integrative, so the number and boundaries may vary depending of the sector or industry. Nevertheless any of proposed by IAM subjects should not be treated as free-standing as there are complex relationships between them.

Prepared by the IAM conceptual model became a basis for the approach adopted by the Conference of European Road Directors within their studies concerning road asset management. Building upon existing knowledge CEDR's Task Group identified 5 main domains which they considered as embracing the implementation of asset management:

- Asset Knowledge and Information,
- Strategy and planning,
- People and organization,
- Stakeholders and customers (including market approach and procurement strategies),
- Risk.

As stated in the report "fully operational asset management system should cover all these dimensions, even though it is fair to say that not every NRA (National Road Authority) may approach it in the same formal manner. Each of these elements is interlinked and bears an important influence of the implementation of asset management within any organization"[15].

AASTHO[16] approach to asset management (which they call Transportation Asset Management) is one of the most comprehensive worldwide. Because according to federal

[15] CEDR technical report 2017/06 – Asset Management TG Final Report 2017
[16] AASHTO Transportation Asset Management Guide, 2011

regulations each and every state has to implement Transportation Asset Management Plans to receive federal funds for road infrastructure, the comprehensive manual for TAM implementation has been prepared concerning:

1. Organization and leading of TAM
2. Processes, tools, systems and data for TAM
3. Examples of asset management plans of local (US) and international agencies.

This guide is a step-by-step presentation of the tasks to implement asset management in a transportation agency, however to better understand implementation strategy, it is recommended to get familiar with the scope of the AASHTO's TAM model as presented below.

In general, framework of asset management proposed in USA comprises of four main areas:

1. Service planning
2. Life-cycle management and asset preservation
3. Program planning and Transportation Asset Management Plan
4. Information systems and data

Area 1: Service planning

This area contains the enabling processes and tools for developing high level agency performance measures that are linked to the levels of service provided to the agency's customers. It also consists of information how transportation planning and growth and demand forecasting are linked to asset management. Risk management is considered as playing a key role in service planning and ability to understand and respond to a variety of risks is treated as an important TAM process.

The outputs of the service planning processes described in this area are typically identified needs for functional improvements to the transportation system.

Strategic performance measurements shall provide information on a wide range of outcomes, such as condition, safety, mobility, and risk. Typically, an agency can report on many other performance measures as well such as output costs, action effectiveness, and utilization. This section provides a framework for establishing these measures.

It is also described, how to link the performance measurement framework with specific levels of service. These influence the quantity and quality of asset provision and can be related to different asset groups, such as pavements, sidewalks, street-lighting, and so on. Defining and agreeing on the right levels of service with the agency's stakeholders and customers is an important planning task for the asset manager.

Moreover, this area consists of:

1. the links between TAM and long-term planning, taking into account the effects of population growth, land use changes, and other changes in the demand for transportation services,

2. approaches to identifying sources of risk, evaluating them, and integrating mitigation actions and strategies into routine business functions of the agency.

Area 2: Life-Cycle management and asset preservation

This area has a focus on the preservation and life-cycle management of the assets. It describes the enabling practices, processes, and tools that support decision making and prioritization for life-cycle management and preservation of the agency's asset portfolio. The outputs include identified needs, such as operational activity, preventive maintenance, rehabilitation, and ultimate reconstruction.

Within process and tools mentioned above, the most important are:

1. asset inventory and its attributes

2. condition and functional performance

3. application of asset inventory, condition and performance data

4. life-cycle management and its links to work activities and decision-making based on condition and functional performance intervention standards

5. life-cycle cost analysis

6. optimized decision making and deterioration models

7. maintenance processes

Area 3: Program planning and Transportation Asset Management Plans

This area consists of the enabling processes and tools that support integrated, cross-function decision making:

1. Program planning (from the phase of candidate projects selection, through trade-offs, up to resource allocation and budget integration.

2. Program delivery - projects development and management and procurement models

3. Asset valuation and depreciation

4. Sustainability, what comprises environmental, social and economic perspectives.

Area 4: Information systems and data

A Transportation Asset Management Information System (TAMIS) is a collection of hardware, software, data, and processes that support asset management business processes. A TAMIS is used to collect, process, store, and analyze information about assets; to develop sound maintenance and rehabilitation strategies; and to schedule, track, and manage work. A TAMIS will typically include:

1. Technical information about asset characteristics, condition, and performance;

2. Financial information concerning current asset value and the level of resources needed to maintain and improve assets to meet established goals and service standards;

3. Planning information about recommended or scheduled work on assets; and

4. Historical information about work accomplished and investments made.

Common functional elements of a TAMIS are:

1. **Asset inventory**—Database that identifies individual assets and their elements, with physical, operational, and administrative characteristics required for developing maintenance and rehabilitation strategies and budgets. Links to maps, photographs, video imagery, or construction plans, or combination thereof, may be included.

2. **Asset condition, performance, and utilization tracking** - current and historical assessments of physical condition and operational performance. Asset management systems may store both raw observations and multiple levels of aggregated or summarized information.

3. **Asset condition and performance prediction**—Capability to predict future asset condition based on deterministic or stochastic models. Some systems include functions to

develop deterioration or performance models utilizing historical data, expert opinion, or a combination of the two.

4. **Treatment selection**—Identification of maintenance, rehabilitation, and replacement treatments that are recommended to be applied to the asset at different points in its remaining life cycle based on maintenance cycles, asset age, or different levels of condition or performance, or combination thereof. Treatment information typically includes (1) rules for when the treatment can or should be applied, (2) unit costs—which may vary by asset characteristics and condition levels, and (3) effect on asset condition or performance when a treatment is applied.

5. **Resource allocation**—Analysis capabilities that estimate the current needs backlog, the budget required to meet a given performance level, the performance that can be achieved for a given budget level, or the “optimal” level of performance that minimizes long-term costs. Some systems address trade-offs across program categories or alternative packages of projects.

6. **Work planning and tracking support**—Automated or partially automated generation of work programs, creation of contract documents, creation of work orders, tracking of completed work, and work histories.

Technology components of a TAMIS are:

1. **Database**—providing core data storage for inventory, work plans, work history, model parameters, etc. Many commercial asset management systems support multiple database types (Oracle, SQL Server, Microsoft Access, etc.)

2. **Links to geospatial features**—providing the ability to view and analyze asset and related information based on location, either through an interface with geospatial data maintained within a separate enterprise database or Geographic Information System (GIS), or through inclusion of geospatial data directly within the asset management database.

3. **Application software**—providing capabilities for uploading, exporting, viewing, and editing data; running analyses; performing queries; and producing reports.

4. **Interfaces**—providing linkages for sharing of data between the asset management system and other systems, which may include budgeting, project programming and scheduling, financial management, work order/maintenance management, trouble-ticket, materials management, time entry, fleet and equipment management, Enterprise Resource Planning (ERP) systems, and enterprise data repositories.

5. **Field Data Collection System**—providing capabilities for viewing and updating inventory and condition information in the field and synchronizing or uploading the data to the master database.

As stated above Asset management extracts value for the organization and its customers. It means it translates the organization’s objectives into asset-related decisions, plans and activities, using risk-based approach. This will enable to achieve desired balance of cost, risk and performance.

What constitutes value, depends on the organization’s objectives, the nature and purpose of the organization and the needs and expectations of its stakeholders. Asset management process therefore supports the realization of value while balancing financial, environmental and societal costs, risk, quality of service and performance related to assets.

ISO defined the Assets as items, things or entities that has potential or actual value to an organization, however this value may vary between different organizations and their stakeholders[17].

This international standard proposes set of fundamental for asset management process which may be described as below:

1. Value – assets exist to provide value to the organization and its stakeholders. It does not focus on the assets as such. This requires:

a. A clear statement of how the asset management objectives align with the organizational objectives

b. The use of life cycle management approach to realize value from assets

c. The establishment of decision-making process that reflect stakeholders' and organization's needs

2. Alignment – asset management translates the organizational objectives into technical and financial decisions, plans and activities. This requires:

a. The implementation of risk-based, data-driven planning and decision-making process

b. The integration of the asset management process with the functional management process of the organization (including finance, human resources, IT)

c. The specification, design and implementation of supporting Asset Management System

3. Leadership – workplace culture as determinant of realization of value, what requires:

a. Clearly defined roles and responsibilities

b. Awareness and competency of employees

4. Assurance – asset management gives assurance that assets will fulfill their required purpose. This requires:

a. The implementation of processes assuring the capability across all life cycle stages of assets

b. The implementation of monitoring and continual improvement

c. Human resources capacity and capability building.

According to the International Organization for Standardization (ISO 55000 et. al), within the benefits of implementation of asset management approach can include:

1. Improved financial performance (i.e. ROI, reduced costs),

2. Optimized decision-making process (data-driven, balancing costs, risk and performance),

3. Risk that is managed,

4. Improved services and outcomes,

5. Improved efficiency and effectiveness.

[17] ISO 55000:2014

7.4 Challenges for infrastructure providers in terms of MaaS and Automated Driving

Adoption of this approach becomes a key enabler for infrastructure providers to contribute to the Mobility as a Service ecosystem because it enhances value by the MaaS customers experience features:

- Directly:

o Journey planning (based on customer personal preferences like time, cost, comfort, convenience)

o Dynamic journey management (as asset management system collects and provides data i.e. in terms of traffic).

- Indirectly:

o Ease of payment

o Ease of transaction

o Personalized service

Nevertheless implementation of full asset management system and adjustment to MaaS needs takes time and also requires consideration of changes in traditional way of doing business by infrastructure providers. From the perspective of MaaS these changes may be described as presented below[18].

Road operations:

- Network management approaches such as Movement and Place[19] and supporting tools like Network Operating Plans[20], may need to be reviewed to ensure they appropriately consider future use cases

- A range of standards, guidelines and regulations will need to be reviewed and updated to ensures the best possible outcomes in implementing automated driving to support consistency of operations which is one of the most important issues for mobility (and automated vehicles)

- Roadworks are also a key aspect and are a particular concern to mobility providers and automated vehicles manufacturers. It is necessary to ensure that road works are well planned and real time information is provided to all relevant stakeholders of MaaS ecosystem. This information should include physical changes to the road layout, which may be more complex for automated vehicles.

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[18] Assessment of Key Road Operator Actions to Support Automated Vehicles, Austroads 2017

[19] "Movement and Place" or what is sometimes referred to as "Link and Place" is a concept and framework which is being adopted by many government authorities internationally to consider and plan our road network and urban environment. The Movement and Place Framework identifies the role of each road through a movement and place matrix (as shown in Figure 3.1). This is based on the strategic significance of the road to move people and goods and the strategic significance of the land use interacting with the road.

[20] This framework outlines the important role of network operations in terms of increasing the efficient use of road network assets. It goes beyond traditional paradigms of the provision of road infrastructure and looks more holistically at the road asset as an operational system for multiple transport modes. Overall system performance and efficiency of the road network as the ultimate goal. Looking at the needs of road users, determining the right mix of infrastructure and non-infrastructure solutions, and focusing the prioritisation of interventions are examples of considerations of the NOP process.

- Improvements in backend systems, services and underlying processes. It can be expected that any type of mobility services will require substantial improvement in content delivery from road authority backend system to feed other service provider backend system but also towards potentially providing data directly into vehicle or mobile devices and/or applications. This communication should enhance intermodal cooperation.

Physical infrastructure:

- Physical attributes: road and intersection design may need to be considered differently depending on the use case that may need to be supported.

- Road pavement and structures: consider changes to loads on bridges, pavements, and barriers, if automated heavy vehicle platoons are to be supported. Road and asset maintenance programs may also need to consider increased loads from platooning. Feedback also suggested that road condition could affect the operation of some AVs.

- Signs and lines: need for consistency in design, implementation and maintenance of road signs and line marking. Existing infrastructure is noted to be problematic for a number of AV manufacturers. There appear to be issues with readability of electronic signs, and therefore greater consideration of machine readability is required when designing signs.

- Roadworks: there is a need for consistency of traffic management treatments which vary significantly between projects and across different jurisdictions. The need for real time information about current road conditions was also highlighted (and further detailed under Digital Infrastructure).

- AV certification: Some agencies have mentioned their consideration of the possible need to “certify” roads as AV compliant. Another approach could be to provide some guidance or framework, outlining where certain AV use cases should or should not operate.

Digital infrastructure:

Digital infrastructure is a key area for consideration in supporting MaaS and the operation of AVs. Data management, positioning services and communication technologies are important areas to be considered, and there are many issues to be addressed to support the rollout of Mobility services and AVs across the road network.

Pertinent issues requiring attention include:

- Road data management – It is anticipated that many Mobility Services and AVs will rely on road map data to operate. These map data products will be provided by service providers. However, there may be some road data attributes for which road agencies are the authoritative source (e.g. speed zone changes, road closures, road works, etc).

- Positioning services: It is clear that many AVs will be reliant upon availability of absolute positioning services. Compatibility of positioning systems with major global vehicle markets and especially Europe and Asia will be important to allow mass produced vehicles to be used on roads. There may be a role for road operators to provide or to facilitate positioning technology in certain locations or scenarios

- Communication services: Availability of communication services, typically cellular, has the ability to enable or preclude AV operation. Road operators typically traditionally do not have to play a role in this space however may need to be more proactive should market forces not provide appropriate services (for example rural areas) or be required to augment services within areas of restricted coverage (e.g. in tunnels or valleys).

- Data ownership: What is the government role in collecting data and how will they share this data? Some companies are proposing the use of open data protocols others are continuing to promote highly silos vertical integrations, intent on controlling data streams.

- Support for proprietary models: A key concern for road authorities is whether support should be provided for proprietary digital infrastructure. For example, if OEMs are to use their own 'clouds' (Volvo, BMW, etc.), will there be something road authorities (or other stakeholders) need to do to support these modalities?

- Standards and guidelines for data are currently non-homogenous in the AV context: Standardization and consistency is very important from a manufacturer's perspective to support AVs.

- Road authority regulatory framework in a digital environment: Road authorities currently manage many regulatory issues such as speed limits, access permits, roadworks, heavy vehicle restrictions, over height restrictions etc. The transition to integrate and maintain this regulatory environment within real-time digital context will be challenging as it may require a significant overhaul of existing systems as well as new skills and changed organizational culture to provide the level of real-time information required. Real time information in regards to roadwork would be highly valuable.

- Privacy and surveillance regulations: Road authorities and other organizations involved in the information supply chain will need to be judicious in regards to the collection and management of data. All data collection, storage, distribution, and utilization will need to be in accordance with relevant laws.

7.5 Conclusions

Infrastructure providers are one of the key stakeholders of Mobility as a Service concept. Their contribution in terms of well managed infrastructure, well planned works or real-time information seems to be crucial for the MaaS implementation.

MaaS also changes the traditional way of doing business thus not concentrating on operations within one sub-sector but concentrating on customer expectations and needs where operations of different infrastructure providers from different sub-sectors have to bring one service. This therefore may enable real intermodality.

Infrastructure providers have to enhance their capabilities in terms of asset management (instead of managing the assets) which will form a basis for providing values and services to the end users. They have to consider challenges in terms of their current operations, physical and digital infrastructure (key processes and resources) considering how todays solutions may become disruptive for Mobility as a Service thus how to change them to become supportive.

Chapter 8.
Conclusions and Recommendations

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