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

**Note by the secretariat**

## Mobility as a Service

## Chapter 1
## Introduction – Mobility as a Service (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 18th/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 concept

The MaaS model covers several concepts that have been extensively discussed in the transportation sector during last decades. These are the integration, interconnectivity and optimization of the transport services, smart and seamless mobility, and sustainability (17). The model also includes concepts that have recently emerged via the Internet of Things and the sharing economy, such as the term "as a service" and personalisation. 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 public transport. 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 is a user-centric, intelligent mobility distribution model in which all mobility service providers' offerings are aggregated by a sole mobility provider, the MaaS provider, and supplied to users through a single digital platform.

Currently, the user has to use numerous tools in order to find information and purchase and access different transport modes. Travellers usually use different journey planning tools to plan their trips. However, most of the existing journey planners do not offer information for intermodal trips (that is, do not combine more than one transport mode – with the exception of walking that is usually the access and egress mode), 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; for example some transport operators only accept cash, other accept cards, smartphone payment or PayPal. Once again, the user mainly needs different tickets/ways to access each mode (recently in many cities around the world, public transport modes are accessed using the same ticket/smartcard, but there is no ticket integration with other transport modes). These are only some of the pain points that deteriorate our mobility and hinder intermodality (refers to the use of two or more transport modes in a trip; 18) or multimodality (refers to the use of different modes for different trips; 18) and the choice of sustainable travel behaviours.

The MaaS concept removes many of these user-related pain points. The MaaS provider is an intermediate between transport operators and users. The MaaS provider uses the data that each transport operator offers (via secure APIs - details regarding how this works are given below), 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 What is MaaS

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."1 Figure 1 illustrates the MaaS ecosystem.

There are four objectives of MaaS, as follows2:

1. Seamless and efficient flow of information, goods, and people both locally and through long distances; 2. Globally scalable door-to-door mobility services without owning a car; 3. A better level of service than the private car; and 4. 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 livability 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

Mobility as a Service White Paper

White Paper 2

network comprised of the operations and infrastructures of multiple trip providers in partnership with each other."3 MaaS satisfies several of the elements of mobility management as follows:4 • 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 traveler 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 vehic

## 1.4 A depiction of Mobility as a Service

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.

## 1.5 MaaS 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.

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

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

**Level One**

Level One represents the loose integration of information into one interface. There are two forms this can take: one-call/one-click centres 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 travellers 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, travellers 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 behaviour. Let’s take driving as an example. Part of what typically pushes travellers 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 fuelled, 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,

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

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).

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.

## 1.6 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.

### 1.6.1 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).

### 1.6.2 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).

### 1.6.3. 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.

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

The Business Ecosystem of Mobility-as-a-Service

Mobility as a Service (MaaS) is a new mobility model that aims to bridge the gap between public and private transport operators on a city, intercity and national level, and envisages the integration of the currently fragmented tools and services a traveller needs to conduct a trip (planning, booking, access to real time information, payment and ticketing). As MaaS gains wider acceptance, there are several misperceptions about what this model is. Thus, the purpose of this paper is to provide a preliminary definition for the MaaS concept, and propose the MaaS ecosystem where the role of each actor is described in details. The MaaS ecosystem is designed after personal interviews and focus groups with the involved actors. This holistic approach sets the ground for the MaaS concept and highlights the areas where research is needed in order to contribute to the materialisation of the concept.

## 1.7 The technology dimensions of MaaS

The platform

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

## 1.8. Drivers and Barriers for Mobility Services Systems

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). 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 for the state to subsidize (Trafikanalys 2016). 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). 2.1.2. Taxation 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 could also create 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. 2.1.4. Availability and standardization of data 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).

## 1.9. State of the Art and Future Challenges with MaaS

### 1.9.1 Demand-Side Modelling

Transport modelling is important and essential for estimating travel demand and offering valuable information to policy makers and transport planners. During the years, several modelling approaches have been explored and formulated. In travel demand modelling, conventional models were aggregate in nature and the dominant approach was the four-step modelling process. Dissatisfaction with trip-based models, policy needs for detailed sociodemographic information for the trip at individual/household level but mostly the behavioural inadequacy of this approach has led to the emergence of disaggregate forecasting models (Bhat&Koppelman,1999). Both supply and demand models have evolved from static to dynamic capturing travel behaviour in terms of time-dependent conditions and information, and from an aggregate to a disaggregate representation of travel, focusing on the heterogeneity of individual traveling (Ben-Akiva,Bottom,Gao,Koutsopoulos,&Wen,2007).

Moving to activity-based approach, new aspects are of crucial importance: integrity, interdependencies between trips of the same trip chain or household, higher temporal and spatial aggregation and a strong behavioural basis, as engaging in an activity in fact 'represents' a dynamic interaction of household needs, tasks, and constraints (Rasouli&Timmermans,2014a).One of the first types of activity-based models were the constraints models, examining the feasibility of agendas with a great emphasis on the role of spatial-temporal constraints on daily travel behaviour. Then, the second approach in activity-based modelling was the econometric one, based on discrete choice models and on the principle of utility maximisation to model pattern formation. Following those, rule-based models (also known as computational process models) have developed, creating activity schedules based on heuristics and decision rules. However, more extended approaches have emerged including time-space prisms and constraints and agent-based modelling (Bhat & Koppelman, 1999; Timmermans, Arentze,&Joh,2002). All these activity-based model systems have been built upon the assumption that travel decisions are made under conditions of certainty. This hypothesis can be considered not realistic, as the state of transportation systems is affected by a variety of uncertainty factors and decision makers don't have a perfect knowledge about their choice set. So, in order to improve the accuracy and reliability of such models, interesting theories and models of human choice and decision-making under risk and uncertainty have been explored and developed in travel behaviour analysis (Rasouli & Timmermans, 2014b). Among these, prospect theoretic models (Kahnema & Tversky, 1979) and regret-based models (Chorus, Arentze, & Timmermans, 2008) are gaining an interest in travel behaviour research in recent years, serving as a valuable alternative to the dominant utility maximisation models. The introduction of uncertainty in the decision-making process should be accompanied by the identification and exploration of other drivers of travellers' choice behaviours, which must be considered in modelling travel demand for innovative mobility services like MaaS in the dynamic and complex context of the smart city.

### 1.9.2. Supply-Side Modelling

The supply side focuses on the modes of transport offered and covers both design and operations. The impact that MaaS has on the supply side can be perceived in the early name that this concept was given in the EU policy scene in 2009: the "Fifth Mode" (Schade, Krail, & Kühn, 2014).There are different reasons why MaaS represents such a disruptive concept for the supply side despite aiming "merely" at a complete integration of the existing modes of transport, and we aim at mentioning the most relevant ones. The integration that MaaS represents has been triggered by the number and variety of new on-demand transportation services that have appeared in the transportation arena. Among these services, we encounter shared services, namely car-sharing and bike-sharing. The one-way configuration of these shared services (the car or bike can be left at the destination and not necessarily at the initial pick-up point), is the one that allows for more flexibility and, therefore, the most suitable for MaaS. The major challenges in designing such services are vehicle fleet optimization and relocation strategies (Cepolina, Farina, & Pratelli, 2014). A step forward needed to bring them further under a MaaS ecosystem would be to take the integrated MaaS supply network into account in these relocation strategies. The effect of autonomous vehicles is another aspect that needs to be considered and that will ease relocation efforts. Research suggests that autonomous cars can rebalance themselves sinthe network and coordinate their actions at a system-wide level (Zhang, Spieser, Frazzoli, & Pavone,2011),solving some of the possible system level problems of car-sharing and Litman (2017) suggests that automatic car-sharing/taxi schemes will become a reality in 2030-40s suggesting a positive impact of automated vehicles on MaaS. Other on-demand transportation services that will play an important role in MaaS are demand responsive on-demand services. They can be classified into individual services, such as regular taxis or Uber-like services, and collective services (e.g. Kutsuplus and Uberpool). The major challenge in modelling this kind of services lies in designing the routing strategy for the vehicles. The routing algorithm to deal with this routing problem has been widely studied and is known in optimisation as the dial-a-ride problem (DARP), which is a generalisation of the Travelling Salesman Problem (TSP). Heuristic search algorithms have been proven to provide optimal solutions for these problems. To control and plan the requests with the desired level of service in the pick-up and drop-off times, the supplier uses the time window approach, as studied, for example, in (Mahmoudi & Zhou, 2016).As an extension of the DARP, the Integrated Dial-a ride Problem (IDARP) includes the integration of demand responsive services with fixed route services. This mode integration scheme shows how the combination of different modes of transport can improve the transportation.

### 1.9.3. Governance and Business Model

An implementation of MaaS can have significant impacts to the existing business model of public transport, especially on the level of integration. An increase in the required level of integration can pose a dilemma for public transport providers in their decisions related to integration with other operators. Traditionally, public transport services are usually provided by monopoly or multiservice providers benefiting from economies of scope and scale (Viton, 1992; Farsi, Fetz, & Filippini, 2007). Apart from the conventional provision of services and its pros and cons, public transport providers might benefit from MaaS, which seems an advanced version of integrated public transport services. Technically, integration of services may be realised by using so-called platform technology, which facilitates interactions between travellers and suppliers of transport services in an improved or smarter way(Ballon,2009;Gawer,2014).Economists perceive platforms as markets which mediate transactions across different customer groups or ‘sides’. Multisided platform (MSP) is a model for MaaS. Besides few practical examples to date, experience can be gained from other industries such as ICT, telecommunications, and airlines industry (Hagiu&Wright, 2015). A crucial characteristic of MSP is the presence of the network externalities (also known as network effects and demand-side economies). Direct and indirect externalities are two types of network effects (Shapiro & Varian, 1999).The direct network effect is that utility of a product increases by growing number of users on the same side of the platform,usuallyforproductinterconnectingpeoplesuchascommunicationtechnologies (i.e. telephone, e-mail, games). The indirect network effect is defined as an effect in which an increase in the number of users on one side is beneficial to other sides of the platform. The indirect effects that arise between users and developers of games stem from two sources: 1) a membership effect, which members on one side enjoy greater benefits of having more members on the other side to potentially transact with, independent of the nature of the product and 2) a usage effect, which users have greater benefits from using better complementary products (Rochet&Tirole, 2003). Additionally, platforms create value by coordinating these services through providing information about the prices and qualities of the services. For example, Uber offers a platform that matches travellers demanding a trip and car owners that want to supply this trip (Gawer, 2014;Hagiu,2014). MSPs reduce search and transaction costs. Search costs are costs incurred by the multiple sides before they interact, to determine the best “trading partners.” (Hagiu & Wright, 2015). Nevertheless, there are certain challenges in establishing a platform, such as the chicken and egg problem (getting both sides to use the platform) and gaining a critical mass of users on both sides in the right proportions to guarantee acceptable

# 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 take off and deliver its potentially large positive effects, it needs to create value for all involved parties – the customers, the commercial and public transport service providers, the cities and regions. Creating viable business models is crucial. Without being able to meet the needs and ambitions of the mobility customers, to make it interesting for the suppliers to be part of an integrated service or to capture enough of the value created to run a business, MaaS won't succeed. Despite all mobility apps 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 Service Providers (TSP) are entering the market and offering various mobility options, such as car sharing, bike sharing, public transport, etc. The result is a fragmented transportation market with a big variety of operators. This makes it for end customers increasingly complex to decide which services would fit best to travel from A to B. At the same time, mobility operators who offer mobility apps to their mobility customers, are looking for a tool to implement a sustainable business model and to facilitate the integration process for their attractive services. By introducing a mobility platform as an enabler for MaaS operators, we will see standardization and platforms that are used by many providers in order to share the cost of development and operation.

## 5.2 The MaaS ecosystem and its key stakeholders

When travelers use different mobility solutions to facilitate their daily journey with a variety of modes of transport, several players, all part of an integrated MaaS ecosystem, come together. An interaction between them is necessary in order to enable a truly intermodal Mobility as a Service solution. Basically, it can be distinguished between Mobility Operators, Transport Service Providers, Cities and Regions as well as Mobility Service Customers, mainly commuters who use mobility 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 really complex with very different types of (in itself non-digital) services and with different conditions in each city.

#### 5.2.1 MaaS Operators

#### 5.2.2 Transport Service Providers

#### 5.2.3 Mobility Service Customers

#### 5.2.4 Cities and Regions

### 5.3 Barriers & obstacles of MaaS operators

The mobility landscape consists of a big variety of Transport Service Providers giving potentially lots of options to solve daily mobility needs even without owning a car. This number is luckily even increase due to additional Ridesharing Services and Demand Responsive Transport Services – School Buses, Night Buses, Special needs transportation for elderly or disabled people – acting as an additional opportunity to solve the user's last/first mile issues. However, this variety of MaaS operators makes it hard for the end user to find the services that would fit best. From a technical perspective the potential MaaS operators 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 MaaS service, most often ending in a non-viable business case when considering the full costs. Specifically, MaaS operators may face problems regarding fragmentation, integration costs, implementation of new services and time management, which can have a significant impact on the successful introduction and maintenance of new services.

#### 5.3.1 Fragmentation

#### 5.3.2 Integration costs

#### 5.3.3 Implementation

#### 5.3.4 Time investments

### 5.4 Being the fifth stakeholder: the MaaS enabler

To enable end-users to benefit from seamless door-to-door mobility, an enriched ecosystem is needed that adapts travellers' choices and offers mobility alternatives provided by as many integrated TSPs as possible to meet people's mobility needs. Introduced as the fifth stakeholder in the MaaS ecosystem, a local mobility platform that can meet the expectations of both MSPs (e.g. central access for all types of mobility, simplified contracting) and TSPs (e.g. increased market visibility) is the key to making MaaS a success. It provides uniform and standardized access to mobility for local MaaS operators. It also enables efficient and transparent management of TSPs and MSPs, including usage-based billing to bill the beneficiaries in the ecosystem of tomorrow. This sets the course for an open and collaborative ecosystem for MaaS.

#### 5.4.1 Role of a MaaS enabler

#### 5.4.2 Key functions in context of the MaaS ecosystem

##### 5.4.2.1 Customer Mobility Hub

##### 5.4.2.2 Mobility Analytics Tool

##### 5.4.2.3 Operation setup: Booking, Ticketing, Payment

##### 5.4.2.4 Intermodal Journeys

### 5.4.3 Advantages for MaaS stakeholders

##### 5.4.3.1 Orchestration

##### 5.4.3.2 Data management

##### 5.4.3.3 Accessibility

##### 5.4.3.4 Integration levels

##### 5.4.3.5 Scalability

##### 5.4.3.6 Adaptability

## 5.5 MaaS areas of use

MaaS opens up the opportunity to look at mobility needs as a whole. What kind of demand exists? What does the target group require to change mobility habits? And where does mobility demand exist? Working in the field of MaaS means answering to different mobility demand models with distinct solutions. In general, the three main demand models – BSC, B2B and B2Government – and combined versions can be distinguished, as the transport services of private, public and commercial providers are becoming increasingly blurred.

#### 5.5.1 B2C

#### 5.5.2 B2B

#### 5.5.3 B2Gov

## 5.6 Case Studies

Different demand models show that not all possibilities of mobility solutions have been fully exploited yet. 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 a handful of cities and regions that have tried to set up innovative mobility solutions by using a central MaaS platform for data management and the technical integration of transport services. They have each found their own way, based on their different starting situations, to use MaaS to improve their local mobility situation.

#### 5.6.1 Stockholm

#### 5.6.2 Helsinki

#### 5.6.3 Aarhus

### 5.7 Recommendations for Cities

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. By working with a MaaS enabler, certain steps that have to be observed on the way to MaaS can be simplified or accelerated.

# Chapter 6. Revenue allocation challenge (Prof. Athena Rouboutsos)

### 6.1 Introduction

[The introduction provides the working definition of MaaS for the Chapter; the description of stakeholders and introduces the issue of MaaS revenues.]

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 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 places, 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. 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, it has the 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 should 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). Operators and integrators need to cooperate to develop packages that customers are willing to pay for (Mulley and Kronsell, in press). 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). However, 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 and especially the public transport operators (i.e. bus, metro, tram, rail). In fact, the role and participation of public transport authorities in Europe is considered critical for a successful deployment of MaaS, while this does not seem to be the case in the United States where public transport is not fully developed (Pöllänen, 2018; Buehler and Pucher, 2012) and emerging mobility service providers are more likely to be the champions of MaaS (House, 2018).

## 6.2. Setting the Scene

[MaaS business models dependent on the potential governance structures, which in turn are also dependent on the transport market regulatory and institutional context. Simultaneously, this context will “push” the innovation evolution in a different direction. This section (possibly combined in the introduction) sets the scene and identifies the potential issues and also guides the direction of the literature review.]

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.

The importance for the user of the MaaS value proposition – and, therefore, user willingness to pay - depends on 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. Notably, MaaS is able to endorse the variety of new on-demand transportation services that have appeared in the transportation arena.

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 her 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 enabled 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.

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 & 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 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 will define both the governance and the business model of MaaS in the various cities, 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.

Figure 1, shows schematically the potential setup of urban transit mobility (UTM), the potential governance models that might emerge for MaaS and initiatives that might be undertaken.

***Fully deregulated*** ← **Urban Transit System** → ***Fully Regulated***

**Shared/On-demand Mobility Schemes**

| | | | | | | |
|---|---|---|---|---|---|---|
| On-demand Mobility Broker | Travel Broker | Alliance of UTS operators & On-demand mobility operators | "Partnership" UTS & On-demand mobility | Alliance of On-demand Mobility providers | On-demand Mobility Broker | ***Potential Business Model*** |
| Return on Investment | Return on Investment | Economic Viability | Social Welfare | Return on Investment | Return on Investment | ***Scope*** |
| Disruptive Commercial Innovation | Destructive Commercial Innovation | Destructive Commercial Innovation | Destructive Policy Initiative | Disruptive Commercial Innovation | Disruptive Commercial Innovation | ***Innovation Type*** |

Figure 1: Schematic representation of potential governance models and MaaS initiatives

Notably, a "broker" at both extremes is the MaaS platform operator. In the one extreme, she operates the on-demand services only, on the other, she might, also, include public transit operators. The latter, might, instead of just opening information channels, wish to be included in the MaaS endeavour in a more active way creating 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.

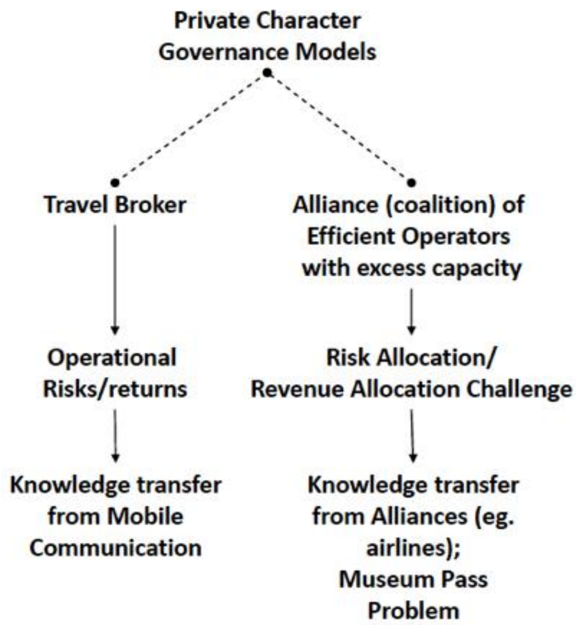
What is of interest, however, is the potential of a "partnership" initiated by the public transport authority. Here, the emphasis is on policy intervention and sets MaaS as a policy initiative rather than a commercial innovation. Moreover, innovation that might bring disruptive changes to urban mobility "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 investments are in great need.

Considering the private governance models, there seems to be a distinction amongst an entity undertaking the role of a "broker", assuming all investment and operational risk, and the formation of an "alliance", where the investment and operational risk is shared. While, many variations may exist between these two setups, the issues that need to be addressed in the two cases are different. In the "broker" case, the business model is based on bilateral agreements concerning data exchange/interface compatibility and provision of availability and the related fare pricing formulae. The "alliance" requires multilateral agreements, interoperability and the challenge of revenue allocation. Moreover, the "broker" will leverage risk by creating "packages" for users exploiting the crowdsourced travel data, while "alliances" would strive on their ability to provide multiple mobility options leading, when considering revenues, to the "museum pass problem" (figure 2). 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 .

Similar problems have been addressed in other sectors, especially the communication sector and the current personal communication market, which has inspired 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".

Figure 2. Governance Models & Revenue Allocation Challenge




## 6.3 Reflection on Current Practice

[This section is a brief description of current practice and how MaaS has been applied to-date. It is highlighted that the revenue allocation challenge has not been addressed yet and that in most cases it has been by-passed, often in non-sustainable ways.]

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 favourable.

Of the 14 MaaS applications listed in Table 1, two have already folded. SHIFT 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 . UbiGo, a spin-off financed by Vinnova, despite meeting project expectations (increased transport options, easier payment, tracking expenditures, and reduced need for private car ownership), was confronted with low revenues due to less than expected car rental and car sharing services and the regulation on the reselling of PT service, which prevented UbiGo from purchasing PT services and making a profit off them. In addition, users needed to pay a minimum amount in advance and they perceived it as less flexible (Jittrapirom et al, 2017).

Of the remaining 12 MaaS applications listed: one is purely a trip planning app (TransitApp); two are publically funded projects (EMMA and Hannovermobil) placing emphasis on the implementation/operation of the projects rather than the revenue streams; seven (Qixxit, Moovel, Switchh, Mobility Mixx, NS-Business Card, Radiuz Total Mobility, Tuup) address different target users providing respective flexibility but with payment systems that are either based on pay-as-you-go (or charge-as-you-go) schemes or redirecting to separate bookings. Therefore, none of the above applications are faced with the challenge of revenue allocation or generating revenues from the mobility service per se. Crowdsource data is commonly used to provide real-time information.

Of the listed MaaS applications, two are of greater interest: STIB+Cambio and Whim. The first is a partnership between STIB (PT and Rail operator) and Cambio (and also other ride-sharing, bike-sharing and park & ride services). The scope of the partnership is to extend STIB services and network using on-demand services. The basis of the partnership is 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 partnership, despite promotions on own services offered in favour of the other partners, continues to receive separate revenues from usage. Whim is closer to the working definition provided herewith for MaaS. It is an investment project. It includes most mobility modes (public and private), its pricing includes three schedules: 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.

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

Table 1. Current MaaS Applications

| MaaS Schemes | Coverage Area | In Operation Y/N | MaaS Operator Type | Urban Public Transport | Bike Sharing | Car Sharing | Car Rental | Taxi | Rail | Parking | Flights | Coach | Description | Revenue Allocation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *STIB+ Cambio* | Brussels | Y | PU | x | x | x | | x | x | x | | | Partnership with on-demand mobility operators to extend Public Transit network. Collaboration in marketing and combination with STIB subscription cards. | Not required. Independent service. |
| *Qixxit* | Germany | Y | PR | | | | | | x | | x | x | A travel planner app. Tickets can only be bought for Deutsche Bahn. | Not required. |
| *Moovel* | Germany | Y | PR | | | x | x | x | x | | | | Daimler AG and BMW Group providing in combination 3 apps: Carsharing, taxihailing, and rail. + travel app. | Not required as separate apps are used. |
| *Switchh* | Hamburg | Y | PR | | x | x | | | | | | | A partnership of 3 car-sharing providers + 1 | Same app, separate bookings |
| *Hannovermobil* | Hannover | Y | PU* | | | x | | x | x | | | | Publically funded project. Promotion of electro-mobility. Registration reduction. | Separate Bookings |
| *EMMA* | Montpellier | Y | | x | x | x | | | x | x | | | This part of the programme “Invest in Montpellier”. The idea is to combine all data sources (not only transport) and provide access to entrepreneurs to use. | |
| *Mobility Mixx* | Netherlands | Y | PR | x | x | x | x | x | x | x | | | Addresses employers and their | Separate charging – a |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | employee business travel. | type of pay-as-you-go but within a budget set by the company. |
| *NS-Business Card* | Netherlands | Y | PR | x | x | x | x | x | x | x | Addressing young entrepreneurs. | Charging-as-you-go |
| *Radiuz Total Mobility* | Netherlands | Y | PR | x | x | x | x | x | x | | Addresses employers and their employee business travel. | Separate charging – a type of pay-as-you-go but within a budget set by the company. |
| *TransitApp* | US, Canada, Europe, Australia | Y | PR | x | x | x | | x | | | Travel/trip planner | |
| *Tuup* | Finland (Turku region) | Y | PR | x | x | x | x | x | | x | Trip planner | Separate bookings |
| *Whim* | Helsinki, Birmingham, Antwerp | Y | PR | x | x | x | x | x | x | | Investment project | Pay-as-you-go & subscriptions |
| *SHIFT* | Las Vegas | N | PR | | x | x | x | | | | Pilot | Close down |
| *UbiGo* | Gothenburg | N | PR | x | x | x | x | | | | Pilot project | Revenues below expectations |

## 6.4 Reflection on Other Sectors

[This is the literature review section.]

Bundling of services and products has been used for decades in various industries (e.g financial, hotels, 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.

## 6.5 The Revenue Allocation Challenge

[This section concerns the methodology that will be applied based on the discussion developed in the previous sections. The text that follows puts forward the "ground" assumptions.]

The revenue allocation scheme should promote "Sustainability", while Mobility as a Service should extend the "Sustainable" characteristics of a public transport system.

According to Roumboutsos et al. (under review) "sustainability" should also be a feature of the "coalition" formulating the MaaS offer. Under these conditions only efficient operators and those we excess capacity are able (and wanted) in the MaaS "coalition". More often than not, public transit systems do not display one or both of the above characteristics and public transit is often subsidized. However, including public transit in the MaaS offer is important, if not to increase public transport ridership, in order to limit or hinder substitution of public transport with car-sharing (Le Vine and Adamou, 2014).

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 as well as other market might serve as an example, their usefulness can only be exploited at a future stage when the MaaS market has matured.

In the meantime, there are three, additional, issues to be addressed:

(1) While users are attracted by the number of available mobility options not all services will be used. Would these partners be compensated? If so, at which level?

Researchers of the Museum Pass problem also include a flat rate in addition to revenue allocated according to revenue allocation rules. Notably, sets of rules could be used to accommodate the needs of each case either in an "alliance" formation of partners (see figure 1) or as a basis for negotiation the pricing of time or tickets if a "broker" is championing the MaaS endeavour.

(2) Public transport is often subsidized. Should subsidization be extended to the MaaS service?

According to Roumboutsos et al. (under review), only efficient operators can be included in the MaaS offer, otherwise economic rationality is not achieved. However, including Public Transport is an important element if policy makers wish to "push" the innovation towards its societal benefits.

(3) Should the MaaS service, given it potential contribution to "sustainability" 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.

## 6.6. Potential Approaches

[Considering the conditions discussed in the previous section, proposed revenue allocation schemes, as well as conditions to include subsidies, will be provided for two pilot cases currently being developed under the MaaS4EU Horizon 2020 funded project.

More specifically, potential revenue allocation schemes will be proposed for the pilot MaaS applications concerning the city of Budapest and the city of Manchester. The two pilots are developed in contrasting contexts: regulated vs deregulated; low vs high car ownership; high vs low public transport ridership, as well as contrasting cultural settings. Consequently, the two pilots could be used as extreme examples of applications for future reference and the development of guidelines. For both pilots alternative governance and business models are developed, therefore, 3-4 cases are anticipated]

## 6.7 Conclusions and Policy Recommendations

[The Chapter ends with conclusions and policy recommendations.]

# Chapter 7.<br>The infrastructure perspective (Mr. Andrzej Maciejewski)

## 7.1 Generic services and value proposition of infrastructure providers and operators

For the deliberations in terms of relations between mobility and infrastructure operators, information about the international best experience in terms of public services and value proposition provided by the infrastructure operators will be depicted in this part of the chapter.

For example, typically road agencies provide two generic activities: road maintenance and traffic management.

Road maintenance 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. Thus road authorities facilitate the value creation of road users by maintaining, upgrading or renewing the infrastructure.

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.

This part of the chapter is a starting point. On that basis in the further parts of the chapter the improvement requirements will be presented, concerning:

- Customer perspective
- Internal business processes perspective
- Learning and growth perspective

## 7.2. Current trends in transportation and a role of infrastructure providers and operators in mobility supply chain

Nowadays we can observe trends in transportation which has been grouped by the UNECE TEM Project as follows:

- Electrification
- Sharing economy
- Automation

Within this part of the report requirements, brought by mentioned above trends in transportation, will be investigated with a special focus on the possible and/or expected roles of the infrastructure operator in the mobility supply chain.

Experiences of specific countries or studies of international organization will be taken into consideration as a case studies.

### 7.3 Identification of new business processes and needs for re-engineering of existing business processes of infrastructure providers and operators

As it has been stated in the first part of the chapter infrastructure operators have their generic services for their customers. To deliver this services they have designed internal business processes. In this part of the chapter impact of the mobility requirements, on the existing business processes, will be investigated and also possible new business processes will be suggested in line with learning and growth perspective.

Experiences of specific countries or studies of international organization will be taken into consideration as a case studies.

## Chapter 8.
## Conclusions and Recommendations