Exploring Strategies for the Implementation of Mobility-as-a-Service in an Urban Context

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Abstract

The transportation sector is undergoing a significant transformation, as evidenced by the pursuit of electrification and the uptake of shared mobility, in addition to the development of other innovative and sustainable solutions. Such a transformation has been fueled by the congestion of established road systems, ever-changing mobility patterns and advances in information technology, which in turn culminated in the development of a new mobility model known as Mobility-as-a-Service (MaaS). By proposing a shift from ownership to access, MaaS emerges as a user-centric, multi-modal alternative to common commuting practices and has harnessed the attention of the public and private sector alike.

The study at hand provides a thorough understanding of MaaS by reviewing its essential characteristics and features, as well as analyzing its business environment. Likewise, it explores ongoing MaaS strategies and implementations at the European level through a benchmark of MaaS services and players. Furthermore, a framework is developed, consisting of 11 proposed criteria against which Business-to-Business (B2B), Business-to-Consumer (B2C) and Business-to-Government (B2G) implementation approaches for MaaS are analyzed and compared. In order to exemplify a use-case for the framework, a case study of MaaS in Lisbon is presented, within which the aforementioned approaches are analyzed through the application of the proposed framework, in addition to providing an overview of the city's mobility context.

The research and European benchmark conducted on MaaS achieves a comprehensive aggregation of key insights, at both the level of MaaS characteristics and its business context, by providing the reader with a conceptually-grounded overview of selected ongoing MaaS developments with regard to the enablers and barriers of each respective area of operation. Furthermore, the proposed framework allows for a structured overview of the key aspects to consider when assessing the prospects of implementing MaaS by diving into each of the criteria and addressing the respective effects and implications, having in mind the key takeaways from the conducted benchmark and MaaS study. By applying the developed framework in a specific urban context, practitioners are also provided with a reference point, should they wish to implement the framework in a similar fashion. In the case of Lisbon, a rich presence of transport operators and shared-mobility service providers, as well as ongoing mobility-enabling initiatives, allowed for a successful application of the framework and thus provided the reader with a practical, city-specific interpretation of the criteria.

Resumo

Estratégias para a implementação de Mobility-as-a-Service em contexto urbano

O setor dos transportes está a passar por uma transformação significativa, evidenciada pela eletrificação da rede e dos veículos, pela adoção crescente da mobilidade partilhada e pelo desenvolvimento de outras soluções inovadoras e sustentáveis. Esta mudança tem sido potenciada pelo congestionamento dos grandes sistemas rodoviários urbanos, pelos padrões de mobilidade em constante mudança e pelos avanços na tecnologia da informação, que por sua vez culminaram no desenvolvimento de um novo modelo de mobilidade conhecido como *Mobility-as-a-Service* (MaaS). Ao propor uma mudança de foco na posse de um veículo para o foco na facilidade de acesso, MaaS surge como uma alternativa multimodal e centrada no utilizador para a prática comum da deslocação, atraindo a atenção tanto do setor público, quanto do setor privado.

Este estudo proporciona uma perspetiva completa sobre MaaS ao rever as respetivas características principais e analisar o contexto empresarial correspondente. O estudo explora ainda as estratégias e implementações em curso de MaaS a nível europeu, através de um *benchmark* de soluções e empresas de MaaS. Adicionalmente, um *framework* é desenvolvido, apoiado em 11 critérios propostos pelos quais as abordagens Business-to-Business (B2B), Business-to-Consumer (B2C) e Business-to-Government (B2G) para a implementação de MaaS são analisadas e comparadas. De forma a exemplificar um caso de utilização para o *framework*, é apresentado um caso de estudo de MaaS em Lisboa, no qual são analisadas as referidas abordagens através da aplicação do *framework* proposto, permitindo também uma visão geral da cidade a nível do seu contexto de mobilidade.

A pesquisa e o *benchmark* europeu realizados agregam conhecimentos cruciais, tanto ao nível das características de MaaS, como ao nível do contexto empresarial, proporcionando ao leitor uma visão geral e conceptualmente fundamentada dos desenvolvimentos em curso de MaaS no que diz respeito aos facilitadores e obstáculos em cada área respetiva de operação. Adicionalmente, o *framework* proposto permite uma perceção estruturada dos principais aspetos a ser considerados ao avaliar a implementação de MaaS, aprofundando cada um dos critérios e abordando os respetivos pressupostos e implicações, tendo em conta as principais ideias-chave do *benchmark* e do estudo de MaaS. Ao aplicar o *framework* desenvolvido num contexto urbano específico, o leitor depara-se com um caso concreto da sua utilização, caso o mesmo deseje implementar o *framework* de um modo semelhante. No caso de Lisboa, uma presença abundante de operadores de transporte e prestadores de serviços de mobilidade partilhada, bem como iniciativas de mobilidade em curso, permitiram uma demonstração clara do *framework*, proporcionando, desse modo, uma interpretação prática dos respetivos critérios de análise ao leitor.

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Thank you all.

"Enjoy the little things in life, because one day you'll look back and realize they were the big things."

Kurt Vonnegut

Contents

Acronyms and Symbols

API	Application Programming Interface
B2B	Business-to-Business
B2C	Business-to-Consumer
B2G	Business-to-Government
CMS	Combined Mobility Services
GTFS	General Transit Feed Specification
HR	Human Resources
IoT	Internet of Things
IT	Information Technology
ICT	Information and Communications Technology
ITS	Intelligent Transport Systems
MaaS	Mobility as a Service
MSP	Mobility Service Provider
NFC	Near Field Communication
OEM	Original Equipment Manufacturer
PSP	Payment Service Provider
PTA	Public Transport Authority
PTO	Public Transport Operator
RPA	Robotic Process Automation
TSP	Transportation Service Provider
UI	User Interface

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Chapter 1

Introduction

1.1 Context and motivation

An ever-increasing trend towards urbanization, paired with developments in multi-modal urban transport and information technologies is catalyzing a paradigm change regarding the way people travel from point A to point B. United Nations (2018) has found that 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050. Consequently, urban transportation networks have progressively been subjected to greater pressure as seen by the effects of excess vehicular traffic, and an overhaul of urban passenger transport systems is becoming a necessary course of action.

Multi-modal transport in the shape of shared mobility and ride-hailing services has been a display of how urban mobility is embodying this paradigm shift. Warwick et al. (2017) have stated in a Deloitte Review issue that (1) carsharing had nearly 5 million members worldwide in 2014, up from around 350,000 in 2006 and is projected to exceed 23 million members globally by 2024; (2) there are more than 1,000 public bikesharing schemes in more than 50 countries — in 2004, only 11 cities worldwide had such programs; and (3) ride-hailing services have seen similarly rapid growth, as seen with Uber's global footprint expanding to more than 500 cities in more than 70 countries. Mobility as a Service (MaaS) stems from the availability of these services, combined with public transport and made possible with information communication technologies (ICT) (Kamargianni et al., 2016; Jittrapirom et al., 2017).

The concept of MaaS reflects the response to the challenges of adapting to multi-modality. Using a variety of public and/or private transport modes and thereby resorting to different payment methods, subscriptions and mobile applications for each operator, alongside a lack of integrated information discourages many people from adopting these services (Kamargianni et al., 2016). MaaS tackles this issue by allowing commuters, tourists or any urbanite with a smartphone to access multiple travel modes made available by the respective mobility/transportation service providers, which are integrated within the MaaS operator's application and provided in the form of packages that can be used and paid for as one commutes (referred to as pay-as-you-go) or in a similar manner as one would subscribe to a media streaming service: a (monthly) fee is charged

and in turn the user gains access to the content available in the platform. Such a comparison is common and has led to MaaS being referred to as the "Netflix of Transportation", as described by Kaj Pyyhtiä in 2017, co-founder of Finnish MaaS operator MaaS Global.

By combining uni or multi-modal journey planning, booking, ticketing, payment and real-time trip updates into a service, the attractiveness of car-ownership is at stake; MaaS aims to get users from point A to point B seamlessly, overcoming typical last-mile challenges with options like bicycles, e-scooters, carsharing or ride-hailing. However, this transition from owning a personal vehicle or relying solely on a public transport subscription to the regular utilization of MaaS is yet to become a widespread reality. In Helsinki - a pioneer city in MaaS adoption - the mobility packages offered by Whim (MaaS Global's mobile application) and mainly aimed at working people who are using several modes of transport, reached 70,000 active users a year after launching the service; although a considerable growth, it only accounted for 6% of the population of the Helsinki region in which Whim offers were available (Cerema, 2019). Nevertheless, the average monthly total cost of car ownership in Europe equates to €616 (as per a 2018 study from LeasePlan), a cost that would be significantly undercut with the utilization of MaaS. This is mainly due to 1) the mitigation of personal registration, insurance, servicing, fuel and other costs, which would instead be distributed throughout the user base; 2) a higher vehicle utilization, due to the inevitable reduction of the total number of vehicles required to satisfy the needs of users within a specific region of operation and 3) the use of public transport infrastructure and other inherently less capital-intensive transport modes (bicycle, e-scooter).

Overarching efforts towards the servitization of mobility are nonetheless a reality and manifest one of the many paths for sustainable urban mobility. The European Union's own project H2020 CiViTAS ECCENTRIC, with a €19M budget and aiming towards the future of sustainable mobility, has fostered the relaunch of one of Sweden's MaaS solutions, UbiGo, among other sustainable initiatives in the cities of Madrid, Munich, Turku and Ruse (European Commission, 2021). Countries such as Germany, the Netherlands, France, the United Kingdom and the United States are all home to several MaaS solutions and initiatives that are reshaping urban mobility; indeed, Juniper Research (2020) estimates that (1) by 2023, the shift to MaaS platforms will have replaced over 2.3 billion urban private car journeys annually - up from 17.6 million globally in 2018 - and have led to annual time savings of 500 millions hours - corresponding to 90 hours every year per MaaS user; (2) by 2027, revenues generated by the use of MaaS platforms will exceed $52 billion, up from $405 million in 2020 and commuter time savings equal to 2.7 days per MaaS user per year. Meanwhile, ABI Research (2016) forecasts MaaS to become a trillion dollar market by 2030.

Advances in key MaaS enablers like Big Data, IoT, mobile applications and 5G, as well as a shift in consumer and societal awareness for greener and less congested cities must be accompanied with dynamic regulation and governmental efforts. It is imperative for legislation to push MaaS in the direction of widespread adoption, as this will provide the needed support for entities who partake in its development whether they be transport (service) providers, authorities or specialized 3rd parties. Strategic collaboration between the public and private sector is pivotal to the effectiveness of MaaS implementation as it leads to the withdrawal of innumerable impediments,

namely at the data level; cities, municipalities and transportation authorities must provide open access to data regarding transportation, this way enforcing public transport as the central element of MaaS yet promoting interoperability between the many parties that make up the MaaS ecosystem.

1.2 Deloitte and the project

The project aimed to conceptualize how Deloitte, a leading global consulting firm, could address the Mobility as a Service market. More specifically, it sought to analyze and compare approaches for the implementation of MaaS by assessing the underlying prospects and implications of focusing on different end-consumers. The project was developed on behalf of the Core Business Operations (CBO) unit within Deloitte Portugal's Business Consulting (BC) division, and intended to aid the company in the future launch of a market offering within the realm of MaaS; as such, the nature of this endeavor corresponded to the effort that must go behind any market offering by Deloitte, thus entailing extensive research regarding the current MaaS paradigm, paired with profound internal involvement as well as regular assessment of key competencies.

For Deloitte, being at the forefront of promising markets is paramount, as it warrants the timely conditions for greater created value. Forthcoming partnerships can be planned, thereby facilitating the business of new or already established players in the sector, whether public or private. Indeed, Deloitte Portugal has vast experience within the smart mobility industry, and has worked together with cities and local authorities to provide these with the necessary digital platform for the efficient coordination and centralization of the many urban service domains, namely mobility, in addition to public infrastructure management, civic protection, emergency management and waste management.

1.3 Objectives

The purpose of this study is twofold. First, it aims to deep-dive into the subject matter of MaaS, doing so through comprehensive research and analysis as well as a benchmark of ongoing European MaaS schemes, where the respective strategies pursued will be explored at the technical, regulatory and economical levels. This provides the necessary foundation for the project's second objective, which is to analyze and contrast Business-to-Business (B2B), Business-to-Consumer (B2C) and Business-to-Government (B2G) approaches for the implementation of Mobility as a Service. Such an objective is achieved through the development of a framework that will be thoroughly explored, as well as applied in a specific urban context.

1.4 Methodology

Initial efforts consisted in getting to know the internal stakeholders of the project, as a means to align overall expectations and objectives. Concurrently, extensive research was carried out as to provide the groundwork for the literature review, where the characteristics of Mobility as a

Service were studied and current MaaS business models and frameworks were analyzed, while also providing an insight on the MaaS ecosystem, that is, which key actors, players and entities are involved and in what way they interact with each other.

A benchmark of MaaS in Europe follows, essentially approaching the topics discussed in the literature review from a more practical perspective by exploring and benchmarking European MaaS schemes and players, at both the feature and business levels. This allowed for a comprehensive overview of the European MaaS context by providing a perspective on not only the characteristics of certain MaaS schemes, but also the strategy pursued with regard to the economic model and technical framework as well as the respective regulatory context of several MaaS implementations and players.

Subsequently, a framework was proposed, consisting of the many criteria against which the MaaS implementation approaches were reviewed and compared, allowing for a comprehensive overview of each approach from multiple perspectives. A case study of MaaS in Lisbon was presented thereafter, in which these identified approaches were contrasted through the application of the developed framework, thus appending additional value to the project while illustrating a specific use case for the framework.

1.5 Structure

The current chapter introduces the project in its respective context concerning the industry, the company, the project's main objectives and inherent methodology. Chapter 2 encompasses a review on the existing literature surrounding MaaS, where its origins and current state of the art will be studied, with respect to its core characteristics and features as well as business context. In chapter 3, European MaaS implementations and players are explored and benchmarked, at both the feature and business levels. Chapter 4 builds upon the literature review and the European MaaS benchmark, proposing a framework to aid in reviewing and comparing consumer-facing approaches for the implementation of MaaS. Chapter 5 illustrates an application of the framework in the context of a case study of Lisbon, and lastly, Chapter 6 concludes the document by discussing the limitations of both the paper as a whole and the developed framework, in addition to proposing future work that may be developed to improve on the conducted study.

Chapter 2

Literature review

The literature review follows the structure presented in Figure 2.1. Firstly, the concept of Mobility as a Service will be explored under the category of Intelligent Transport Systems, where its current state of the art is reviewed along with the core characteristics, followed by an analysis on the proposed topologies and classifications of MaaS. A holistic approach to the business environment of MaaS was then undertaken, addressing the perspectives of both the business ecosystem and the business models of Mobility as a Service.

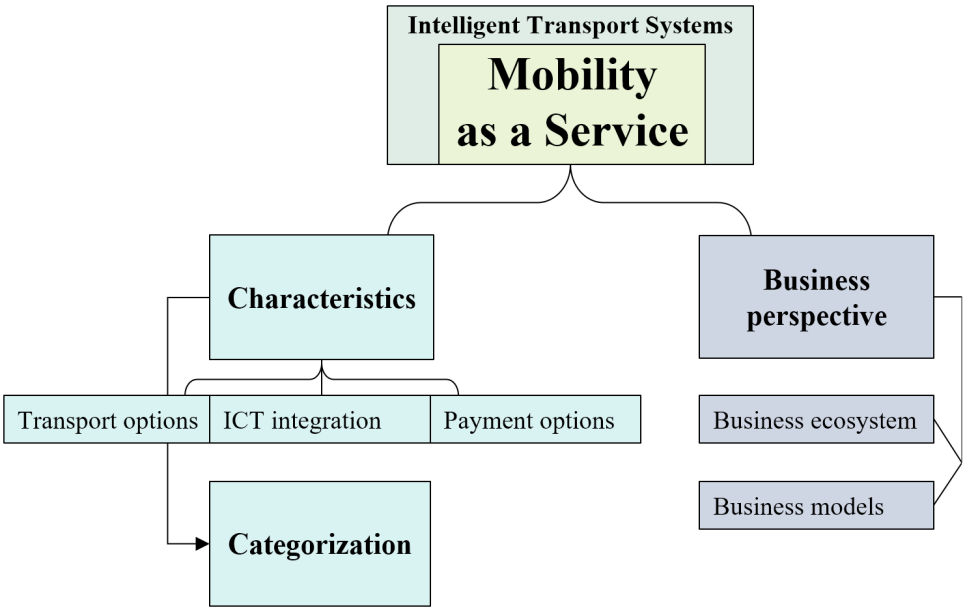

Figure 2.1: Literature review structure

2.1 Mobility as a Service and Intelligent Transport Systems

In spite of not being unanimously and universally recognized under the exact same terms given its relatively recent inception (Jittrapirom et al., 2017; Kamargianni and Matyas, 2017; Sochor et al., 2018), the notion of Mobility as a Service nonetheless covers concepts of integration,

interconnectivity and optimization of the transport services, smart and seamless mobility, and sustainability (Kamargianni and Matyas, 2017). As such, MaaS lies within the realm of Intelligent Transport Systems (ITS), which are defined according to the directive of the European Union 2010/40/EU as systems in which information and communication technologies (ICT) are applied in the field of road transport, traffic management and mobility management, as well as for interfaces with other modes of transport (European Union, 2010). In more practical terms, the application of the aforementioned ICTs aims to achieve an improved traffic flow, enhanced safety and decreased environmental disadvantages, which in turn generate advantageous services for users within an ecosystem and establish an increasingly convenient use of multi-modal mobility services (Heikkilä, 2014). Information is therefore the fundamental element and catalyst in ITS, as it shapes the ecosystem in which transport systems move goods and people (Costantini et al., 2019) and is the key enabler of the proactive synergy occurring between the various elements of an ITS.

MaaS leverages advancements in ITS within urban (public) transportation such as real-time inter-modal journey planning enabled by the availability of real-time fleet information, smart ticketing, and automated fare collection systems, benefiting both operators and urbanites by making services easier to utilize. According to Hietanen (2014), the MaaS model aggregates these services and distributes them to the consumer over one interface in order to meet a customer's transport needs. On the other hand, Jittrapirom et al. (2017) refer to MaaS not as a model, but as (1) a concept, i.e a new idea for conceiving mobility, (2) a phenomenon occurring with the emergence of new behaviors and technologies or (3) a new transport solution which merges the different available transport modes and mobility services. In the interpretation of Kamargianni et al. (2016), Mobility as a Service refers to the practice of buying mobility services as either packages based on consumers' needs or as pay-as-you-go, where MaaS users pay for the transport service(s) as they commute. Holmberg et al. (2016) advocate a similar definition, highlighting the notion of Combined Mobility Services (CMS) as a particular subset of MaaS containing several transport modes offered in a single subscription to the customer. Kamargianni and Matyas (2017) later summarized and conceptualized MaaS as 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". Whilst a complete and valid definition, Sochor et al. (2018) affirm that with such a multitude of different mobility services (e.g multi-modal travel information, integrated ticketing services or bundled mobility service providers), defining all of these heterogeneous services under the same loosely defined term generates confusion and might potentially compromise the concept's potential as it "can then be perceived as merely the latest buzzword; a new name for the same thing"; accordingly, the authors provided a topology for the various levels of MaaS integration (where, for example, level 1 equates to information integration as seen in applications/services like Google Maps or Moovit, and level 3 equates to service offer integration as is the case with apps like UbiGo and Whim), so that a more comprehensive discussion, understanding and comparison of different services can be achieved (the particular topology proposed by Sochor et al. (2018) and other authors will be explored in section 2.3). Nonetheless, Sochor et al. (2018) promote the idea that, no matter the definition or

description, MaaS is most generally about (1) offering a service with customer/user/traveler/consumer transport needs as the main focus; (2) offering (multi-modal) mobility rather than transport and (3) offering integration of transport services, information, payment and ticketing.

Several definitions have highlighted the significance of technology-enabled connectedness. Particularly, the crucial role of ICT in the emergence of MaaS is emphasized by Audouin and Finger (2019) as well as Kamargianni and Matyas (2017), where the former identify three key disruptions of ICT in the transportation sector that have supported its advent: (1) the development of integrated multi-modal information systems, allowing users to access and compare specific travel information from various transportation providers in real time, and thus choose the solution that best meets their mobility needs, (2) digitalization, aiding the development of integrated ticketing and payment methods, allowing users to access multiple modes of transportation with only one payment method thereby promoting multi-modal travel, and (3) the emergence of specific mobility solutions enabled by ICTs through development of dedicated digital platforms, enabling people to connect more easily with one another, and even in some cases to propose mobility services by themselves. Such innovative solutions include car-sharing, carpooling, and ride-booking.

MaaS involves many key players and stakeholders, that not only differ between each location of implementation, but also add to the inherent complexity of the whole system. The notion of an ecosystem helps categorizing key elements of MaaS such as the transport or IT infrastructure, transportation services, transport information and payment services (Hietanen, 2014; Kamargianni and Matyas, 2017; Warwick et al., 2017) and will be further analyzed in section 2.4. Additionally, it stands to reason that the presence of many players and stakeholders corresponds to the existence of multiple drivers that enable, encourage or catalyze the movement towards the new transport paradigm of MaaS. These were summarized by Holmberg et al. (2016) and classified in a threefold manner into (1) societal drivers, such as urbanization, urban densification, climate change, the sharing economy and Millennials as a generation, (2) economical drivers, including the urgency for monetizing excess or idle inventory and the increase in financial flexibility, and (3) technological drivers, which include the widespread use of mobile devices (i.e smartphones) and the ever-increasing availability of online platforms that enable the servitization of transport.

It has been claimed that the future of mobility greatly depends on its servitization and that this embodies the departure from how mobility has been delivered until now (Poggi et al., 2019; Warwick et al., 2017). In particular, Warwick et al. (2017) frame MaaS against three particular revolutions of transport, (1) the 19th century industrial era, where railways and fixed public transport networks supported the concentration of population and employment in newly emerging cities, (2) the arrival of the car in the 20th century, which, paired with its mass-production, led to the rise of suburbanization and decentralization of activities outside city lines and (3) the 21st century digital age, in which MaaS is included, and where the advent of the “information everywhere” paradigm has opened up new possibilities to make the existing transportation network significantly more efficient and user-friendly via expanded consumption options and convenience.

2.2 MaaS characteristics

In the face of countless interpretations by multiple authors, identifying central, user-oriented, front-end Mobility as a Service characteristics allows for a more concrete analysis and thorough understanding of the concept itself. Following a literature review regarding the many proposed definitions of MaaS and its current state of the art, a triad of core characteristics proved to be recurrent and are therefore identified and explored in the following subsections.

2.2.1 (On-demand) transport options

It is by aiming to determine the most appropriate mode(s) of transportation for the user that MaaS is able to meet the user's mobility requirements (Barreto et al., 2020) - as such, the inclusion of multiple transport modes is and has been central to the very concept of MaaS (Hietanen, 2014; Finger, Matthias; Bert, Nadia; Kupfer, 2015). The question, however, of which transport modes to offer in a MaaS solution is key, as these must enable a balanced blend of door-to-door capabilities and urban sustainability, while utilizing the city's existing transport infrastructure. Juniper Research (2020), Cerema (2019), Ramboell (2019), Trafi (2020b), Holmberg et al. (2016), and others enforce public transport as the core of Mobility as a Service; indeed, Ramboell (2019) found that 95% of trips made by Whim users in Helsinki were with public transportation, and that the overall public transportation modal share for these users (taking into account trips made without the Whim application) is 63% - a comparable non-MaaS user group in the Helsinki metropolitan area represented a significantly lower 48%. Jittrapirom et al. (2017) state that the use of public transport is encouraged by bringing together multi-modal transportation and allowing urbanites to choose and seamlessly integrate these modes in their inter-modal journeys; taxi, car-sharing, ride-sharing, bike-sharing, car-rental and on-demand bus services were the modes highlighted by the authors that may be included in a MaaS application. To further support the inclusion of such services, Kamargianni and Matyas (2017) advocate working on the convergence of various private transportation modes, as integrating public transportation alone is insufficient to distinguish themselves from single-mode transit providers; furthermore, the authors explore how the transport providers themselves benefit from MaaS by mentioning how these will gain access to a wider market as compared to acting alone. As a result, there might be more private transport providers interested in integrating the MaaS solution, which only adds to the importance of collaboration between all the different providers - this way, both the private and public sector may aim to achieve their respective goals, whether they be a profitable business model, or public policy benefits like higher productivity, fewer traffic accidents and a lesser need for vehicle parking space (Warwick et al., 2017). Jittrapirom et al. (2017) accentuate the importance of car-sharing and bike-sharing in adding flexibility (the vehicle can be left at the destination and must not necessarily be returned to the initial point) and therefore becoming suitable and ideal for MaaS - however, such flexibility brings challenges in conceptualizing said services, namely the imbalance of available vehicles, which requires optimization and strategic vehicle relocation efforts (Cepolina et al., 2014).

2.2.2 ICT integration through a digital application/platform

According to Kamargianni et al. (2016), "ICT integration in transport refers to a centralized platform that assembles information of various modes". Such platforms that help users select and compare various modes of transportation to their destinations have become ubiquitous, with local and global alternatives accessible in every region, most of them being offered to the users either through a smartphone application or a website (e.g Google Maps, Moovit, Citymapper, Transit). However, for one to purchase the planned journey in effect, the paradigm is such that usually multiple apps relating to the select modes of transportation are needed (Barreto et al., 2020) - an example of such a situation could be as follows: buying a single public transport ticket from the public transport authority/operator's mobile app to commute from point A to B, then launching the NextBike app to rent a bicycle that will get one from point B to C. The concept of MaaS, on the other hand, envisages a single digital mobility platform (Jittrapirom et al., 2017; Kamargianni et al., 2016; Finger, Matthias; Bert, Nadia; Kupfer, 2015; Hietanen, 2014) - ideally a mobile app - through which the end-users can access all the necessary services for their trips (trip planning, booking, ticketing, payment, and real-time information) (Jittrapirom et al., 2017) and therefore carry-out their journey across a range of transportation modes based on their own preferences regarding time, comfort, cost and/or convenience (Warwick et al., 2017). A visual representation of this concept is displayed in Figure 2.2.

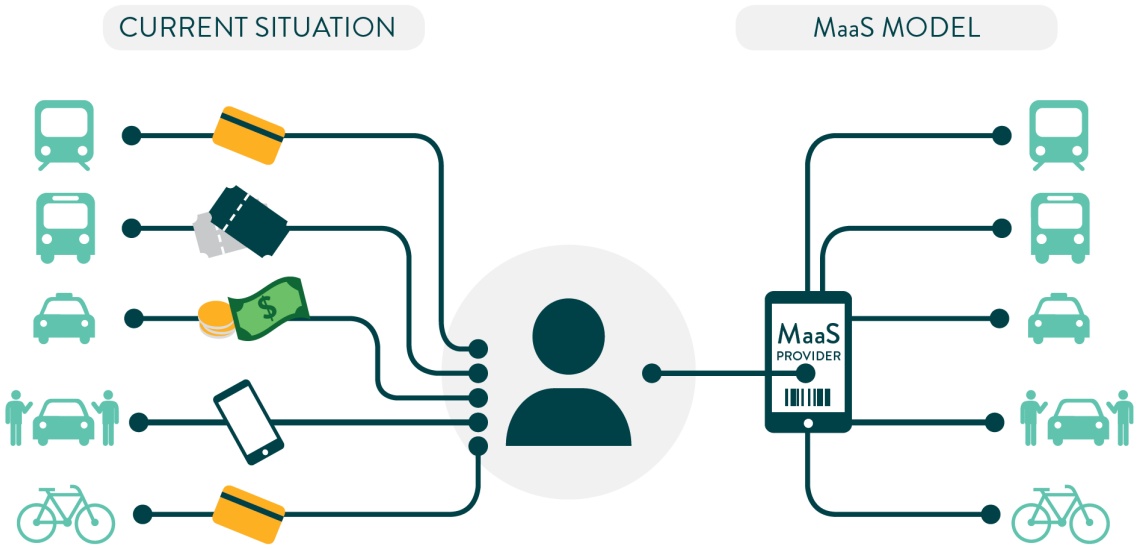

Figure 2.2: Conceptual visualization of the transport integration through a digital application, reproduced from UITP (2019)

However, the integration level of these features varies significantly; for instance, where one particular MaaS application is able to integrate payment, journey planning and subscription options, another might only integrate the first two functionalities. Furthermore, and depending on the availability of mobility service providers in a particular area, some MaaS schemes might integrate public transport as well as car and bike-sharing, whereas another MaaS scheme might have

the opportunity to include electric micro-mobility as well (e-moped, e-bike); as mentioned previously, section 2.3 further explores the proposed classifications of MaaS regarding the level of integration. In order for the ICT integration to be possible, however, the MaaS provider must be able to process customers' requests and data in real time, which requires an extensive coverage of high speed internet (3G/4G/5G) (Kamargianni and Matyas, 2017). Stopka (2014) highlight the importance of innovative mobile app features; the authors found that the user demands for these are growing (i.e. personalized trip advice through the app) and that these help to stimulate the emergence of developments within the realm of MaaS applications.

2.2.3 Pay-as-you-go or mobility package/subscription options

Users can typically choose between two forms of tariffs when using MaaS, either pay-as-you-go or a (monthly) mobility subscription/package (Jittrapirom et al., 2017; Warwick et al., 2017; Capgemini Invent, 2020; Kamargianni and Matyas, 2017; Kamargianni et al., 2016). The package offers bundles of various transport modes, previously purchased in bulk by the MaaS operator and passed along with a discount (Warwick et al., 2017). The package includes a certain amount of km/minutes/points that can be utilized in exchange for a monthly payment (Jittrapirom et al., 2017). The pay-as-you-go charges users according to the effective use of the service, where a trip "can be organized as a single trip chain, but the user would then pay separately for each leg" (Jittrapirom et al., 2017; Holmberg et al., 2016). Furthermore, the MaaS providers could offer business-to-customers (B2C), business-to-business (B2B) services or both, i.e offer services to individuals, as well as companies for their employees' business trips (Kamargianni and Matyas, 2017). The use case for mobility packaging is relevant as it has been used to maximize the use of modes that are included in the package, as shown in transport pass/season ticket literature (Kamargianni et al., 2016); Studies from Axhausen et al. (2000) and Simma and Axhausen (2001) have demonstrated how owning a season public transport ticket favored using public transport as opposed to other modes of transport. Schad et al. (2000) discovered that 90% of users in the study sample no longer kept their personal car, as the mobility package included a seasonal transport pass and access to car sharing and car rental.

2.3 MaaS categorization

Achieving fully integrated and seamless multi-modal mobility is the fundamental idea behind Mobility as a Service (Kamargianni et al., 2016). However, the level to which a particular MaaS application is able to integrate many aforementioned characteristics and features like information services, payment services, booking, ticketing, and to which it can enable the systematic collaboration between different transport providers varies extensively. For instance, bundling many different transport modes through a (monthly) subscription is ultimately desirable but it is still not as common as, for example, the less integrated pay-as-you-go tariff (whereas the former is able to integrate the service offer through bundling/subscription/contracts, the latter calculates the value of each trip individually).

As a result, multiple authors deemed necessary to propose a classification of MaaS. Holmberg et al. (2016) did so by presenting two different models; the first model would classify MaaS based on the criteria of complexity and novelty (the result were 7 different levels, ranging from "simplified car ownership" to "Mobility Broker"). The second model positioned MaaS against the dimensions of level of system integration (Y-axis) and ownership (X-axis) of transport assets in the available services. Kamargianni et al. (2016) differentiated MaaS in a threefold manner: (1) partial integration (meaning that the MaaS scheme in question partially possesses ticket, payment, and ICT integration); (2) advanced integration without mobility packages (the scheme completely possesses ticket, payment, and ICT integration) and (3) advanced integration with mobility packages (the MaaS implementation completely possesses ticket, payment, ICT integration, and mobility packages). The authors later developed an integration index to differentiate available MaaS platforms at the time of the study. Sochor et al. (2018), while recognizing the former's work, proposed a topology of MaaS that would otherwise explore its implications, as well as the "how and why" of such a classification. The authors describe the resulting topology as a "tool for facilitating the discussion of MaaS, enabling the 'comparison of' different services, understanding MaaS' potential effects, and aiding the integration of societal goals into MaaS services". The result consisted of MaaS levels 0 to 4, ordered by increasing integration of features, and was and is widely accepted and regarded as an adequate framework for differentiating MaaS applications (Figure 2.3).

Level		**Description**
0	No integration (Single, separate services)	This is the most simplistic level, in which separate services are offered for each mode of transportation with no form of integration.
1	Integration of information (Multi-modal travel planner, price information)	Travel information is integrated and provided at this stage by travel planners, which may or may not provide route and expense information. The added advantage of Level 1 is that it aids in deciding the right trip (regarding time of the day, route or transport mode(s) used).
2	Integration of booking and payment (Single trip - Find, book and pay)	This level may be a natural extension of a travel planner, allowing for the addition of public transport ticketing, taxi, and other transportation options where applicable. It provides commuters with easy access to services through a one-stop shop where they can search, book and pay, all in one app (with a pre-registered payment card, for example), and increases client exposure for transport service providers.
3	Integration of the service offer (Bundling/subscription, passes, contracts, etc.)	This level represents a more holistic alternative to vehicle ownership, focusing on the customer's full mobility requirements and increasing the appeal of transportation service providers to consumers that otherwise wouldn't exist when offered as single services. Individuals and families' regular mobility needs are also met by the service, which provides various modes of transportation through passes, packages, bundles or subscriptions.
4	Integration of societal goals (Policies, incentives, etc.)	MaaS goes beyond coordinating the demand for and availability of mobility at this level. The added advantage is reduced private car ownership and usage, resulting in a more affordable, livable community, and so forth.

Figure 2.3: Proposed topology of MaaS, adapted from Sochor et al. (2018)

Lyons et al. (2019) presented a taxonomy of MaaS comparable to the level 0–5 SAE taxonomy for automation of road vehicles. While Sochor et al. (2018) focus upon the perspectives of the customer, provider and business, Lyons et al. (2019) opted for a user-oriented approach, where the perspectives of cognitive user effort, as well as operational, informational and transactional integration are explored (Figure 2.4).

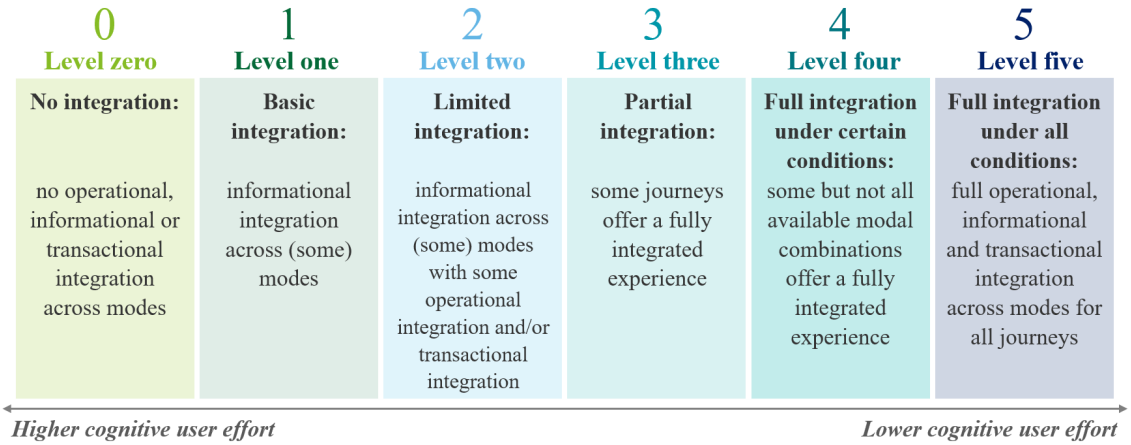

Figure 2.4: Conceptualisation of the levels of MaaS integration, adapted from Lyons et al. (2019)

As seen above, the higher the level (0–5), the greater the integration in terms of the aforementioned perspectives and the lower the cognitive effort required by the user to utilize a MaaS application of a particular level.

The classifications, taxonomies or topologies proposed for MaaS enforce the fact that not all services are equivalent as they target different customer needs; in fact, these help to clarify the MaaS discussion, deepen understanding of challenges and enablers at various levels, and promote MaaS growth, for example, by action plans customized to the desired MaaS level and objectives (Sochor et al., 2018).

2.4 The business perspective of MaaS

The successful implementation of MaaS necessitates the integration of aforementioned core functions such as booking, ticketing, and multi-modal traveler information systems, as well as the combination of multiple transport modes and services; nevertheless, in order for cities to transition from their current mobility paradigm to MaaS, a range of factors must be considered and tackled, including organizational and technological criteria, as well as, and most importantly, business feasibility (Polydoropoulou et al., 2020). The authors also emphasize how the success of MaaS is dependent on recognizing the specific characteristics of each implementation area (e.g city or region) in order to design suitable business models, which take into account the MaaS operator's mission, objectives and strategy and are capable of delivering the required business viability to the involved actors while reacting flexibly to the needs of cities and end users.

In this section, literature regarding both the MaaS business ecosystem and models will be explored. These are related in the sense that new entrants entering the current MaaS business ecosystem are projected to have a huge effect on current transport operators' business models, and in order to stay sustainable in the changing ecosystem, MaaS stakeholders must change their value generation processes (Polydoropoulou et al., 2020).

2.4.1 MaaS business ecosystem

The concept of "business ecosystem" first appeared in a Harvard Business Review article (Moore, 1993), where the term is defined as "an economic community supported by a foundation of interacting organizations and individuals (the organisms of the business world) that produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders. Over time, they coevolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies".

Defining the business ecosystem of many industries or emerging product/service trends has been a common practice, and MaaS is no exception, with contributions from a number of authors to describe the MaaS business ecosystem and specify the players involved and their positions within it. As mentioned before in section 2.1, the notion of an ecosystem helps categorizing key elements of MaaS - transport or IT infrastructure, transportation services, transport information and payment services (Hietanen, 2014; Kamargianni and Matyas, 2017; Warwick et al., 2017) - where all the players have the same goal of providing a hurdle-free mobility experience and maximizing the advantages of each service to improve the transportation network.

Within the context of the research project "MAASiFiE", König et al. (2016) claimed there are 4 levels to the MaaS ecosystem, these being the public and regulatory level, the transport and logistics service providers level, the mobility service level and the end-user level. The authors also differentiate between supply and demand sides, where level 2 corresponds to the former and level 4 to the latter. Level 1 encompasses players like local authorities (related to land use, infrastructure, transport planning) and level 3 includes the MaaS operator. Holmberg et al. (2016), however, identify the following components of the MaaS ecosystem: Combined Mobility Service (CMS) provider, CMS operator, Public Transport, Platform Service Provider (PSP) and the Mobility manager (i.e the City). The authors further explore how these interact with each other and what the roles of each are. In this case, the CMS provider is identified as the business ecosystem leader, where its objective is to scale and grow the service. The report shows that there are business opportunities for MaaS operators, platform providers, mobility service providers as well as for public transport if the particular MaaS implementation is designed in an ideal manner. Transport Systems Catapult (2016) highlight the presence of four main stakeholders that together form the MaaS ecosystem and present how value is provided by each of these actors to the ecosystem itself; (1) the customer(s) demand a certain service and in turn obtain it from (2) the MaaS Provider(s) (or operator). The MaaS Provider will then demand certain information from (3) the Data Provider(s) who in turn deliver data regarding specific insights and actions to take. Lastly, the Data Provider(s)

demand certain data from the many (4) Transport Operator(s) who transmit these data to the Data Provider.

García et al. (2020) tackled the topic of the MaaS ecosystem from the perspective of electric mobility, where an overview of the state of the art regarding electric Mobility as a Service (eMaaS) ecosystems and architectures was carried out. The authors aimed to support the further development of eMaaS by proposing a definition and a novel system architecture for eMaaS, and thus defined it as "the integration of multiple forms of eco-friendly transportation modes - including human-powered vehicles and electric public transport - and shared electric mobility services (e.g., e-car sharing, e-bike sharing, e-scooter sharing, e-bus, e-taxi) into a single mobility service that allows travelers to plan and go from A to B (and/or from B to C and/or vice versa) in an eco-friendly and seamless way". One key difference between the MaaS and eMaaS ecosystems is that in the case of the latter, shared electric mobility acts as the backbone of transport, as opposed to public transport, which usually represents the centerpiece of transport offerings to urbanites within most of European MaaS implementations.

To further amplify the notion of "business" within the term "business ecosystem", Kamargianni and Matyas (2017) define the latter - in the context of MaaS - as “the wider network of firms that influences how the MaaS provider creates and capture value”. According to the authors, it consists of several actors, including transport operators (i.e mobility service providers), data providers, technology and platform providers (i.e technical back-end providers), ICT infrastructure, insurance companies, regulatory organizations, universities and research institutions. Kamargianni and Matyas (2017) differentiate multiple layers to a market ecosystem (Figure 2.5), each of which corresponds to different degrees of commitment to the MaaS provider:

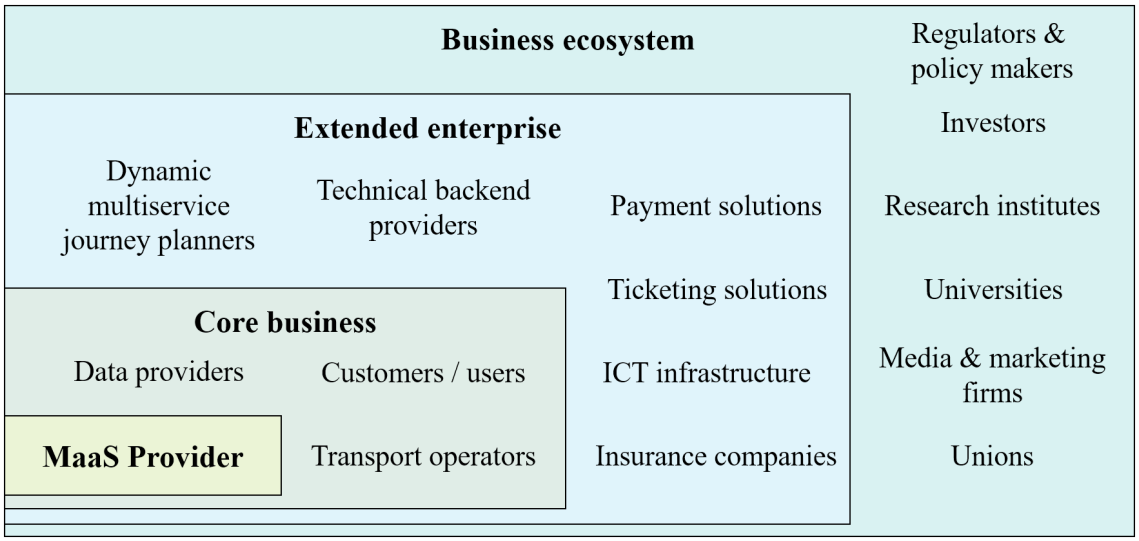

Figure 2.5: The Mobility as a Service ecosystem, adapted from Kamargianni and Matyas (2017)

The first layer i.e the ecosystem’s core business layer consists of the MaaS provider itself (the focal firm) and the parties forming the centerpiece of the business. The next layer, the extended enterprise, broadens the view of the business supply chain to include the complementors

and second-layer suppliers. The outermost layer i.e the business ecosystem adds stakeholders including regulators, unions, universities and other research bodies, and investors to the business ecosystem.

The roles of the more relevant actors within the MaaS business ecosystem (i.e. those within the "Core business" layer in Figure 2.5) are described below, with the addition of "Technical or technology providers" and "Ticketing and payment solutions providers" (the latter are included in the "Extended enterprise" layer of Figure 2.5).

- **The MaaS provider or operator** role can be undertaken by different players, although a public transport authority (PTA), a public transport operator (PTO) or a specialized MaaS firm are usually the most appropriate entities for such a position. The MaaS provider is responsible for crafting the framework which fosters the many mobility service providers (MSPs), so that urbanites can be provided with multi or inter-modal transport. Thus, it must negotiate and handle contracts with the right MSPs as to ensure that the mobility needs of the city are appropriately met. The MaaS provider may either handle itself all the integrations and communications between the many MSPs' systems by possessing or buying the necessary technology, or it may outsource such operations. As an example of the latter, Trafi, a Lithuanian start-up specialized in providing the technological platform for multiple European Mobility as a Service solutions (i.e a MaaS technical provider), upholds all the integrations and communication between the many MSP systems included in Jelbi - Berlin's MaaS application, provided and operated by the Berlin's public transport authority BVG.

- **Mobility service providers (MSPs)** negotiate their capacity with the MaaS operator and grant access to their data via secure APIs (Application Programming Interfaces) and thus represent a key component within the core business ecosystem as a main supplier to the MaaS provider (Kamargianni and Matyas, 2017). MSPs provide mobility services through various transport modes: traditional MSPs include public transport operators (PTOs) of bus, rail or metro services, in addition to other established transport operators, whereas car-sharing or e-scooter companies represent more recent MSPs. Other MSPs might include parking space companies and electronic toll collection companies. As mentioned in section 2.2.1, MSPs via the MaaS provider have the opportunity to access a wider market and increase their market share. Furthermore, by understanding the market and capability of transport operators in real time, the MaaS operator could maximize demand and supply which would be particularly useful during peak hours, where certain transportation providers are at capacity and the MaaS provider might divert demand to other operators, avoiding customer frustration (Kamargianni and Matyas, 2017).

- **Technical/technology/platform providers or service aggregators** could be seen as the main digital enabler of MaaS. These are responsible for managing and enhancing (and, in some cases, capturing) the necessary mobility data to enable the supply of multi-modal travel to the MaaS provider, and thus to the end consumers of the MaaS implementation.

The technical provider achieves this by creating, supplying and operating the integration platform that connects and manages the many MSPs, and manages the data transfer between said MSPs, the mobility app and the customers. However, the desirable architecture of each MaaS providers' platform will most likely vary with the idealized MaaS implementation and business model. Technical providers may be specialized third parties, or they can also be integrated as a core division or segment of a MaaS provider. For example, the WienMobil app (one of Vienna's MaaS implementations) is operated by Wiener Linien, the local PTO, and was developed by the technical provider Upstream Mobility, a subsidiary of Wiener Linien; in this case, however, the technology that originated Upstream Mobility's platform had been previously bought by Wiener Linien from Fluidtime (a renowned technology provider in the field of MaaS headquartered in Vienna) (Cerema, 2019). Upstream Mobility therefore developed their digital platform not from scratch, but rather with technology and technical expertise bought from a third party. Whereas technical providers usually offer a holistic service encompassing most of the MaaS operator's digital needs, a **Data provider** will focus in offering data and analytics capabilities to MaaS providers by processing and repackaging the data of the transport operators and collecting data from a range of other sources (i.e. customers' mobile phones, social media etc.), later making this data available to the MaaS operator in interoperable formats (Kamargianni and Matyas, 2017). Thus, most technical providers do in fact incorporate the role of data providers as well, as is the case of Trafi, which captures mobility data as to provide multi-modal travel for the users of the Jelbi app in Berlin. Conversely, in the case of Moovizy (St. Etienne's MaaS implementation), real-time data retrieval is carried out by HERE Technologies, whereas technical provider Cityway was responsible for the development of the platform, aggregating and interfacing the many MSPs, as well as real-time journey planning, booking, validation and payment (by resorting to HiPay, a payment service provider). Since both Trafi and Upstream Mobility specialize in providing the platform and front-end for city authorities' MaaS schemes, they are considered Business-to-Government (B2G) MaaS platform providers. REACH NOW, on the other hand, aggregates the MaaS technology for its own application, made available to the general consumer, and thus operates as a Business-to-Consumer (B2C) MaaS provider. However, it has also provided its MaaS solutions for the employees of software development company Mbition and innovation lab Lab1886 (both companies opted for having mobility budgets in the form of MaaS rather than company vehicles), which means that REACH NOW has also operated within the Business-to-Business (B2B) MaaS sector. A B2B technical provider can also be considered a B2B MaaS provider, since it ultimately manages the provision of MaaS to that company, similar to how B2C MaaS providers (as described in the first bullet-point) manage the provision of MaaS to cities' urbanites (regardless if these are responsible for the technical implementation of the service or not).

- **Customers** are the main catalyst of MaaS. If customers and society as a whole are unable to derive value from MaaS, then any implementation efforts will be ill-fated. The promise

of hassle-free, cost-effective, and customized mobility aims to achieve this value. As previously mentioned, the customers could be individuals, companies or both, based on the business model of the MaaS provider (B2C, B2B, B2C&B2B) (Kamargianni and Matyas, 2017).

- **Payment service providers (PSPs) or ticketing and payment solutions providers** offer advanced modes of payment and ticketing with credit cards, smartphones, linking PayPal accounts and digital wallets (Kamargianni and Matyas, 2017), enabling customers to purchase their MaaS trips more seamlessly. PSPs manage the payments for the services of MSPs, where the former charges money from the users and directly transfers it to the latter, with little interference from the MaaS operator or the technical provider. The technology a MaaS provider will choose depends heavily on the PTO's ticketing mechanisms; as such, an ideal solution should be found so that the customer is able to access as many transport modes as possible with one ticket (Kamargianni and Matyas, 2017).

2.4.2 MaaS business models

A business model, in general, assists in the identification of critical elements such as (1) the business concept, i.e. what problem are you solving and for whom, (2) the way consumer value is generated, (3) the sales and costs that can be expected, (4) the path of the product or service to consumers, and (5) the business's approach to long-term competitiveness. However, and similarly to the concept of Mobility as a Service, there is no exact definition for the term (Zott et al., 2011); nevertheless, a substantial amount of literature exists concerning its many interpretations. Amit and Zott (2001) frame business models as "the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities" and later build on this definition by adding the notion that a business model represents a "system of interdependent activities that transcends the focal firm and spans its boundaries" (Zott and Amit, 2010). While Chesbrough and Rosenbloom (2002) maintain the central position of value within the concept of business model, defining it as the "heuristic logic that connects technical potential with the realization of economic value", Morris et al. (2005) propose a broader view on the matter by describing the term as a "concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets". The authors nonetheless highlight the role of the value proposition by including it among their six suggested fundamental components of business models; customer, internal processes/competencies, external positioning, economic model, and personal/investor factors represent the remaining five.

Developing sustainable MaaS business models is critical to ensure that consumers' necessities and expectations are addressed and to reach collaboration of multiple players within a single mobility platform (Mulley and Kronsell, 2018). Furthermore, Polydoropoulou et al. (2020) advocate that appropriate MaaS business models should consider (i) the actual and future transportation

landscape of each deployment area (e.g, ongoing or proposed mobility services in a city, transport-related technical advances in the region, and so on); (ii) the actors from various fields, such as transportation and information technology (IT), and their future collaboration within MaaS; (iii) the new sources of revenue and new cost structure within the MaaS scheme and (iv) the opportunities and potential barriers to MaaS implementation and how these differ from one another.

As part of the aforementioned research project "MAASiFiE", König et al. (2016) provided an early contribution regarding the classification of existing MaaS schemes into different MaaS operator models. Firstly, the two most common MaaS business models and revenue streams of MaaS operators are identified: 1) the agency model, primarily based on reselling, where the MaaS operator purchases transport tickets in a significant volume and thus receives a volume discount and 2) the merchant model, which essentially works through commissions paid to the MaaS operators by transport operators (the former resells the services of the latter and receives a commission). The authors then distinguish four different MaaS operator models: 1) the Reseller model, supplying transport services of different transport modes; 2) the Integrator model, that, in addition to the Reseller model, combines the services of several modes with digital services (i.e a front-end MaaS application for mobile ticketing and travel planning); 3) the Public transport operator model, where PTOs act as MaaS operators by integrating additional transport services and digital services with their existing public transport and 4) the Public-Private-Partnership (PPP) model, where different categories of players and services may be integrated into the scheme by the public actor, resulting in a rationalization of the services the public actor is responsible for.

König et al. (2016) also presented a general business model for a MaaS operator and services using Osterwalder's business model canvas framework. Holmberg et al. (2016), however, applied this framework to the specific case of the UbiGo MaaS scheme in Stockholm and described the potential role of public transport in a MaaS scheme, identifying the PTO's plausible position in a MaaS scheme as a coordinator (MaaS operator) or collaborator (partner). Polydoropoulou et al. (2020) employed this framework years later to develop their generic prototype MaaS business model (Figure 2.6); according to the authors, the business model canvas framework is mostly used by researchers and practitioners for the description, analysis and design of a business model, with König et al. (2016) even stating that it is "probably the best-known tool for business model construction", which is in all likelihood why the previously mentioned authors employed such a tool to develop their own proposal of a MaaS business model.

Figure 2.6 includes the nine building blocks of the business model, namely key partners, key activities, key resources, value propositions, customer relationships, channels, customer segments, cost structure and revenue streams. The prototype business model aims to "include all promising partners, serving all possible customer segments and exploiting all probable resources", thus considering the full potential of the ideal MaaS scheme (Polydoropoulou et al., 2020). The authors later adapted the generic business model canvas to the local conditions and particularities of each of the three particular study areas (Budapest, Greater Manchester and Luxembourg) as to provide city-specific prototype business models for MaaS, thus delivering more tangible knowledge to (i) potential MaaS operators, who might utilize the generic business model components to not only

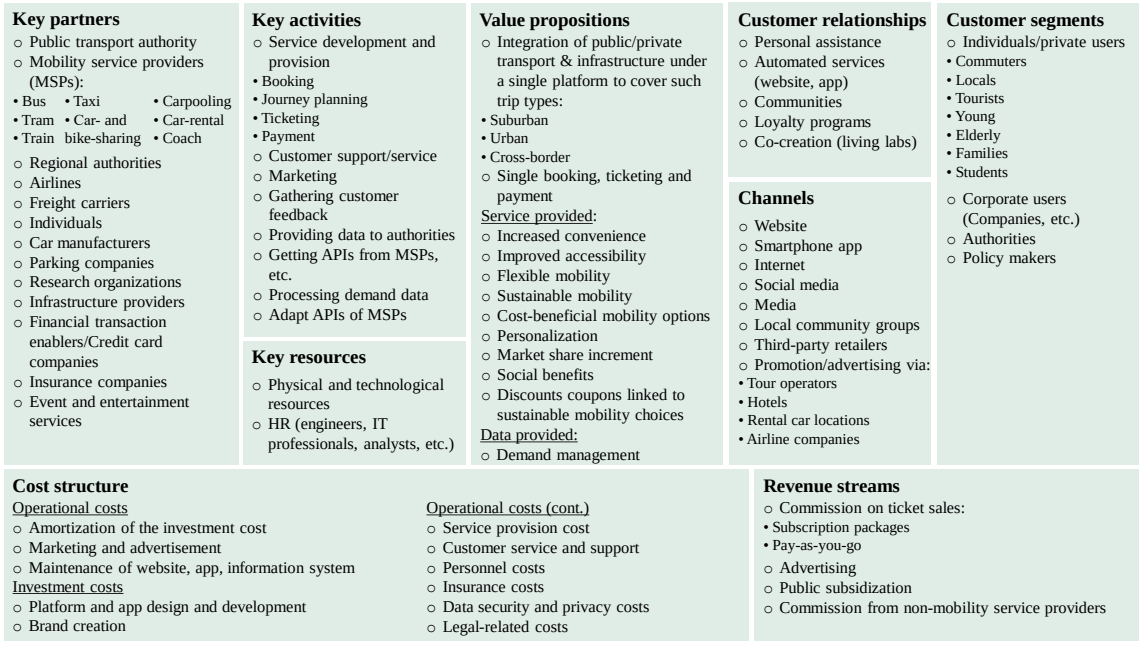

Figure 2.6: Generic prototype business model for MaaS based on Osterwalder's Business Model Canvas, adapted from Polydoropoulou et al. (2020).

help them make decisions, but also to motivate MSPs to offer customized services; (ii) potential MaaS partners, who could consider the framework when considering their participation in a MaaS scheme; (iii) city governments, considering implementing a MaaS scheme in their city, who "could consider the opportunities and challenges identified to promote related investments, develop future transport policies and potentially use MaaS as a travel demand management tool."

Chapter 3

Benchmarking MaaS in Europe

The aim of this chapter is to tackle the topics discussed in the literature review from a more concrete and practical standpoint. As such, a benchmark of European Business-to-Consumer (B2C) MaaS implementations was carried out, enabling a comprehensive comparison of said schemes at two general levels: firstly, the selected MaaS schemes will be framed in accordance to both the core features and the proposed classifications highlighted in sections 2.2 and 2.3, thus constituting the feature-level benchmark; the business-level benchmark follows, where a further selection of these schemes will be compared with regard to their economic model, their regulatory context and their technical framework, as well as the entities that compose its business ecosystem.

Following the B2C benchmark, a MaaS operator and a technical provider operating in the Business-to-Business (B2B) and Business-to-Government (B2G) sectors were analyzed. These, of course, tackle MaaS with a distinct approach and target market (as mentioned in section 2.4.1), since the former targets companies aiming to provide their employees with MaaS (as opposed to, for instance, a company vehicle), and the latter targets cities wishing to deliver MaaS to their residents, commuters and tourists. As a result, certain differences and similarity trends surfaced among the B2B, B2C and B2G companies and schemes under analysis, and the previously studied concepts of MaaS were successfully translated to an up-to-date operational level. It is important to note that the benchmark has not distinguished or highlighted a MaaS scheme or player in particular by setting it as the reference among the others; instead, the benchmark was conducted with a purely comparative approach, focusing on translating the concepts and topics presented in the previous chapter.

3.1 Initial selection of B2C MaaS schemes

The methodology behind the initial selection process consisted in, firstly, filtering the numerous MaaS initiatives and implementations currently operating in Europe. These were identified succeeding a review of MaaS literature, including grey literature and white papers, and research. Mobility services whose features didn't correspond to the previously identified core characteristics were excluded as to provide a degree of consistency within the proposed set of schemes. For

instance, Tripkey, operating in the Netherlands, is a mobility service that enables commuters to access multiple transport modes (train, bus, tram, subway or city bike) through a dedicated travel pass; nevertheless, the service doesn't include an integrated journey planner accessible through a mobile device, essentially missing out on the key feature "ICT integration through a digital application/platform" (section 2.2.2) and thus isn't included. The inclusion of both public and private transport services was a filtering criterion as well, referring to section 2.2.1 as to highlight how: 1) the use of public transport is encouraged by bringing together multi-modal transportation and allowing urbanites to choose and seamlessly integrate these modes in their inter-modal journeys (Jittrapirom et al., 2017); 2) working on the convergence of various private transport modes is pivotal, as public transportation alone is insufficient to position the public transport operator (PTO) in an advantage compared to other single-mode transport providers (Kamargianni and Matyas, 2017); 3) private MSPs such as car-sharing and bike-sharing are essential to bringing flexibility to a given MaaS implementation (Jittrapirom et al., 2017). Thus, MaaS schemes incorporating only private or only public transport options were not considered. Furthermore, all but one of the proposed set of MaaS schemes were operational at the time of inclusion (UbiGo ceased operations in March 9, 2021, due to COVID-19-related losses), and all of them targeted the general consumer (B2C).

The result of this initial selection is displayed in Figure 3.1: in total, 20 schemes operating in 10 European countries were identified.

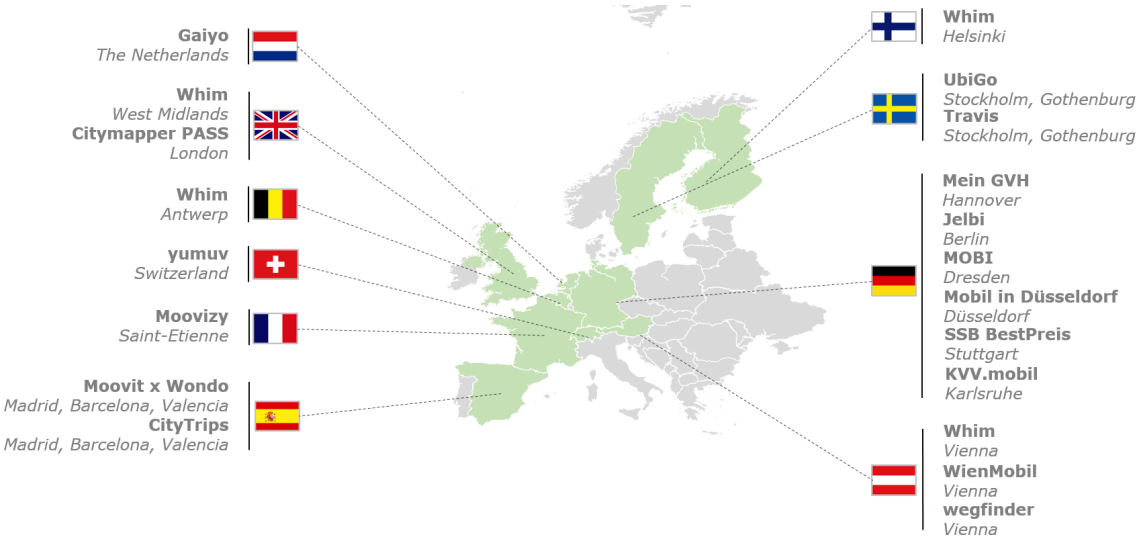

Figure 3.1: An overview of European MaaS schemes (B2C)

3.2 B2C feature-level benchmark

The following stage consisted in narrowing the initial selection of MaaS schemes as a means to conduct a more concise and relevant analysis. Accordingly, a preference was attributed to schemes whose area of operation was exclusively urban (for instance, yumuv, a regional MaaS

scheme spanning the cities of Zurich, Bern and Basel, was excluded) since it resembles the scope of the present project. Furthermore, commercially implemented MaaS schemes were prioritized, as opposed to pilot-stage MaaS efforts (Gaiyo, a MaaS scheme operating in the Netherlands, is still at its pilot-stage and is only expected to be fully commercially launched following the end of 2021). Schemes that operate in multiple cities and/or countries were only considered in their most relevant area of operation (Whim, for example, operates in several urban areas worldwide but only Helsinki was considered in the feature-level benchmark, a city in which it not only started, but also where the respective Whim-implementation is comparatively most feature-rich and where most data was gathered). Lastly, availability or lack of information on a particular scheme proved to be a major selection criterion as to assure a reliable and accurate benchmark.

10 MaaS schemes were the outcome of the above-mentioned narrowing efforts, constituting therefore the feature-level benchmark (Figures 3.2 and 3.3). Three of these MaaS implementations operate in Germany, two in Spain, and the remainder spread across the United Kingdom (London), France (Saint-Etiénne), Sweden (Stockholm), Austria (Vienna) and Finland (Helsinki). As mentioned in section 3, the schemes were analyzed according to the core features and characteristics of MaaS presented in section 2.2. However, "ICT integration through a digital application/platform" was split into two distinct components in the benchmark - "Functionalities" relates to what the digital platform can offer to the consumer feature-wise, whereas "ICT integration" analyzes the extent to which this feature-offer is integrated in the particular MaaS implementation. Moreover, the MaaS implementations were framed according to the MaaS classifications presented in section 2.3, particularly the topology proposed by Sochor et al. (2018); as a result, most of the analyzed MaaS schemes were classified as Level 2, with Citymapper PASS and Whim representing the only Level 3 implementations, and Moovit X Wondo the only Level 1 MaaS scheme. This means that most of the analyzed schemes will integrate booking and payment, but won't bundle subscriptions or packages.

Certain characteristics weren't included in the benchmark as they were present in all the MaaS schemes. Examples of these include the use of GPS technology (a necessity for route-planning and mapping features) and the ability for one to register in-app. Information regarding userbase or other scheme-specific details are included in the last row of the feature-level benchmark.

3.3 B2C business-level benchmark

In this section, three of these MaaS schemes will be evaluated with respect to their technical framework and their economic (or pricing) model, as well as their respective public policy and regulatory context. Two of these schemes correspond to the only Level 3 MaaS applications benchmarked in the previous section (Citymapper PASS and Whim); however, these are both private sector initiatives, and as such, WienMobil was elected as the remaining scheme, as it represents not only an implementation led by local authorities, but also one that stays true to the MaaS concept by providing some level of integration on a comprehensive service offer.

MaaS Scheme	CITYMAPPER PASS	CITYTRIPS	MEIN GVH	JELBI	KVV.MOBIL
Current areas of operation	London (UK)	Barcelona, Madrid and Valencia (ES)	Hannover (DE)	Berlin (DE)	Karlsruhe (DE)
Area under analysis	London (UK)	Barcelona (ES)	Hannover (DE)	Berlin (DE)	Karlsruhe (DE)
Transport options and associated services	Aggregates data and allows for the use of: Public transport; (e-)Bike–sharing; Ride-hailing; Taxi Aggregates data for all other urban modes of transport with the standard Citymapper app	Aggregates data for: Public transport; (e-)Bike-sharing; (e-)Moped-sharing; (e-)Car-sharing; Ride-hailing; Taxi; Parking	Aggregates data and allows for the use of: Public transport; Car-sharing; Taxi Aggregates data for: Bike-sharing	Aggregates data and allows for the use of: Public transport; Bike-sharing; (e-)Moped-sharing; e-scooter-sharing; Car-sharing; Taxi	Aggregates data and allows for the use of: Public transport; Bike-sharing; e-scooter-sharing; Shuttle service Aggregates data for: Car-sharing
Payment options	(Weekly) subscription / package options and pay-as-you-go in other zones across London	Pay-as-you-go	Multiple public transport tariff options or pay-as-you-go	Multiple public transport tariff options or pay-as-you-go	Multiple public transport tariff options or pay-as-you-go
Functionalities	Real-time information; Route planner; Booking ((e-)bike and taxi); Payment; Public transport ticketing	Real-time information; Route planner	Real-time information; Route planner; Booking (taxi); Public transport ticketing	Real-time information; Route planner; Booking; Payment; Public transport ticketing	Real-time information; Route planner; Booking (except for car-sharing); Payment (except for car-sharing); Public transport ticketing
ICT Integration	Mobile App; integrates booking, ticketing and payment (except for ride-hailing which requires third-party app), paired with subscription / package options	Mobile App; booking, ticketing and payment requires in-app redirection to respective third-party apps	Mobile App and website; integrates booking for taxis and car-sharing (payment requires redirection) and ticketing. In the case of bike-sharing, only route-planning is available	Mobile App; integrates booking, ticketing and payment for all modes of transport	Mobile App; integrates booking, ticketing and payment (except for car-sharing which requires third-party app)
MaaS Level	Level 3	Level 1	Level 2	Level 2	Level 2
Technical provider	Third party	Third party	Public transport authority	Third party	Third party
Further details		60000+ users (2018)		55000+ registered users (2020); 13000 vehicles (2020)	Will later merge with KVV.regiomove, adopting its name in the process

Figure 3.2: B2C feature-level benchmark of selected MaaS schemes

MaaS Scheme	MOOVIT X WONDO	MOOVIZY	UBIGO	WIENMOBIL	WHIM
Current areas of operation	Madrid, Barcelona and Valencia (ES)	Saint-Etiénne (FR)	Stockholm, Gothenburg (SE)	Vienna (AU)	Helsinki, Turku (FI), Vienna (AU), Antwerp (BE), Tokyo (JP), Singapore and West Midlands (UK)
Area under analysis	Madrid (ES)	Saint-Etiénne (FR)	Stockholm (SE)	Vienna (AU)	Helsinki (FI)
Transport options and associated services	Aggregates data and allows for the use of: Public transport; Taxi; Aggregates data for: Bike-sharing; e-moped-sharing; e-scooter-sharing; Car-sharing	Aggregates data and allows for the use of: Public transport; Bike-sharing; Car-pooling; Car-sharing; Taxi; Rail Aggregates data for other transport in the Rhône-Alpes	Aggregates data and allows for the use of: Public transport; Bike-sharing; Car-sharing; Car-rental; Taxi	Aggregates data and allows for the use of: Public transport; Bike-sharing; Car-sharing; Taxi;Rail; Aggregates data for: e-moped-sharing; e-scooter-sharing; Car-rental; Other (e.g parking)	Aggregates data and allows for the use of: Public transport; Bike-sharing; e-scooter-sharing; Car-sharing; Car-rental; Taxi; Regional train
Payment options	Pay-as-you-go	Pay-as-you-go with monthly billing for public transport and bike-sharing; pay-as-you-go (car sharing and taxi)	Monthly subscription for public transport, bike and car-sharing; pay-as-you-go (car rental and taxi)	Multiple public transport tariff options or pay-as-you-go	(Monthly) subscription / package options or pay-as-you-go
Functionalities	Real-time information; Route planner; Booking (taxi); Public transport ticketing	Real-time information; Route planner; Booking; Payment (except for car-pooling); Public transport ticketing	Real-time information; Route planner; Booking; Payment; Public transport ticketing	Real-time information; Route planner; Booking (bike sharing, car sharing and taxi); Public transport ticketing	Real-time information; Route planner; Booking; Payment; Public transport ticketing
ICT Integration	Mobile App; integrates booking (taxis) and ticketing. All other transport modes require app-redirection for booking and payment	Mobile App; integrates booking, ticketing and payment (except for car-pooling which requires third-party app)	Mobile App; Integrates booking, ticketing and payment for all modes of transport	Mobile App; Integrates booking for bike+car-sharing and taxi (payment requires redirection), and ticketing. With other modes of transport, only route planning is available	Mobile App; Integrates booking, ticketing and payment for all modes of transport, paired with subscription / package options
MaaS Level	Level 2	Level 2	Level 2	Level 2	Level 3
Technical provider	Third party	Third party	Third party	Public transport authority	Third party
Further details	Partnership between mobility giant, Moovit, and Wondo; 87000 users (2020)	26000 regular users (2019)	Started as a pilot in Gothenburg (2013-2014) in one of the first ever trials of MaaS; Ceased operations in March 2021	Developed and succesfully tested in a commercial pilot (SMILE project); 1M+ downloads (2020)	2M+ trips made (Oct 2018); 70000 registered users (2018); 8500 subscribers in Helsinki (Jun 2019)

Figure 3.3: B2C feature-level benchmark of selected MaaS schemes (continued)

This analysis, paired with the B2B and B2G analysis in section 3.4, will provide the groundwork for Chapter 4.

3.3.1 Citymapper PASS, *London*

The information presented in the following subsections has been sourced from articles, reports and grey literature such as Urban Transport Group (2019), Transport Committee (2018), Warwick et al. (2017), Dixon et al. (2020), Akyelken et al. (2018), European Commission (2017), Burrieza (2019), Citymapper (2019a), Field (2020), KnowWhere Consulting (2019), Gabert-Doyon (2019), Citymapper (2019b), Hern (2019), Taylor (2021) and Ackerman (2021).

3.3.1.1 Overview

Citymapper is regarded as a reference among transit apps and mapping services for its high level of information integration and intuitive UI. It currently incorporates data for various urban modes of transport including walking, cycling and driving, with a particular focus on public transport. Unlike the regular Citymapper public transit and mapping app, which currently operates in 86 cities worldwide, the PASS is a MaaS scheme exclusive to London. It was launched in 2019 and provides two subscription options to many of London's mobility services as a card/pass-based MaaS solution binded to Citymapper's app.

The 'Super Pass' is priced at £33/week, providing unlimited public transport within certain zones and pay-as-you-go in other zones across London, thus essentially providing a similar service to the ubiquitous Oyster card from Transport for London (TfL) - the city's main transport strategy and planning authority - except for the fact that it is paired and integrated into the Citymapper app. The 'Super Duper Pass' is priced at £40/week, adding bike-sharing in the form of unlimited 30 minute trips with Santander Cycles, as well as including a £10 weekly credit which can be utilized on either Gett's Black Cabs, Lime e-bikes, or FREE NOW ride-hailing.

3.3.1.2 Technical framework

The app is owned and operated by Citymapper Limited, and it integrates data from a variety of modes of transportation in numerous regions. These underlying data arise from a number of sources, including open data - typically General Transit Feed Specification (GTFS) files made available by PTAs -, local transit authorities, user-generated data, and data gathered by locally employed people.

The PASS solution incorporates ticketing and payment integration to an already established multi-modal journey-planning app, in the form of a contactless-ready card (issued by Prepaid Financial Services Ltd.) which suits the already frequent contactless payments occurring within the public transport network in London. Since the PASS is able to integrate with smartphone wallets, users can use Citymapper exclusively with their NFC-enabled smartphone, providing true pay-as-you-go similarly to the Oyster card, with, however, the benefits of real-time journey-planning. However, unlike bike-sharing and taxis, which are both fully integrated within Citymapper PASS,

FREE NOW and Lime both require one to book the service from the respective app and use the PASS as the payment method.

3.3.1.3 Regulatory context

Over the last few decades, significant changes in the UK's transport policy have occurred, such as the deregulation of transportation and the resulting privately-led operation of most services, causing a shift in the public sector's role to establishing a wide regulatory framework and undertaking certain actions in situations where the provision of services isn't adequate, by, for example, providing subsidies. Particularly, and still at a national level, efforts from the United Kingdom's central government supporting the development of MaaS have mostly been materialized in the form of plans or visions; the 'Future of Mobility' was identified as one of the Grand Challenges in the 2017 Industrial Strategy, aiming to set the UK as a pioneer in defining the upcoming path for mobility. Accordingly, the UK's 'Future of Mobility: Urban Strategy' published in 2019 lays out the road map for future mobility and respective guiding principles in the UK's metropolitan regions. Furthermore, the House of Commons Transport Committee's final 2018 report on Mobility as a Service identified several actions for the Department for Transport (DtF) to undertake, as to maximize the advantages of MaaS (while preventing adverse outcomes), such as 1) providing guidance and support for the UK's development of MaaS, and 2) reviewing guidelines and regulation to create an appropriate regulatory environment for MaaS in the form of, for example, policies that facilitate and support data exchange between MaaS providers and MSPs.

At a local level, and particularly in the case of the UK's capital, the governance system at hand is rather complex; the decision-making mechanism is fragmented and decentralized (generating challenges within policy-making) and the road network's ownership structure is equally elaborate and as such, TfL has complete authority to provide guidelines for and supervision of transport. However, it doesn't intervene in choices of the particular Boroughs on land usage - for instance, this governance approach proved to be a hurdle for car-sharing company car2go, which abandoned London in 2014 due to challenges operating in a fragmented governance environment, where parking permits, for example, had to be sought separately from each London Borough.

Nevertheless, TfL did follow Helsinki's model (section 3.3.3) after its widespread praise within the transport policy-making realm and opened-up its transport data, resulting in the emergence of a myriad of apps who use these data (TfL has no own app; rather, it provides over 8,000 developers with its API), including Citymapper. TfL also introduced EMV contactless ticketing and payment systems for most forms of transportation, using an "aggregated pay-as-you-go" method to fare collecting, allowing passengers to make several multi-modal journeys by just tapping in or out with their contactless credit card. Such a system was leveraged on the existing high level of integration between London's major public transport services, and resulted in 55% of trips being paid with this system by 2019. Furthermore, it supplied useful information on when and where people utilize transportation, which served as a catalyst and enabler for attaining MaaS.

Certain initiatives that would ordinarily be undertaken by public authorities could also be led by private organizations. For instance, banks have sponsored London's bike rental program (as a

result, Citymapper PASS lists Santander Cycles as one of its included means of transportation), and contribute roughly 10% of the running costs and an extra amount towards extending the service coverage. This benefits both the city, which is now able to offer a more comprehensive array of mobility services, and the bank, which now has access to the information of the people who sign up, in addition to achieving larger governmental objectives (while providing the company with branding opportunities as well as increased visibility).

Outside of London, however, challenges such as data availability/sharing between the many operators are still more apparent, as in most other metropolitan areas, the regulatory framework regarding transport data is not as MaaS-oriented, i.e PTOs and MSPs might not be required to share data. Some key-people within the transport sector argue that more needs to be achieved outside of London that replicates TfL's data policy, and that this depends mostly on nation-wide regulatory advances. Nonetheless, cities and metropolitan areas in the UK are working to encourage mobility developments, such as The West Midlands, which received £20m for the UK Government to become a 'Future Mobility Area', thus having hosted the UK's first commercial MaaS trial of MaaS Global's Whim (which is now commercially available in The West Midlands). Further smart mobility efforts may be found in Oxford and Oxfordshire, as well as Greater Manchester, where the local PTA, Transport for Greater Manchester, has participated in a number of EU-funded research programs to investigate MaaS and other transportation technologies.

3.3.1.4 Economic model

Citymapper Limited increased its income to £5.8M in 2020 from £516,000 in 2019. However, it still had a net loss of £8.9M. Furthermore, Citymapper had accumulated losses of £21.8M until December 2018 and of £31M until December 2019. Since its inception in 2011, and similar to companies like Uber and Lyft, Citymapper has gathered the financial resources to operate and expand its service, despite losses, primarily through investment funding rounds; indeed, the Citymapper userbase has reached 50M in 2021, which attracts the organizations (investors in Citymapper include Index Ventures and Balderton Capital) that recognize the vast value of data sourced from Citymapper's position at the center of a large network that is able to obtain precise information regarding the commuting routines of millions of citizens. Accordingly, Citymapper raised just over £10.4M in new equity in 2020 and a total of £45M as of April 2021. Four years prior, in the funding round of 2016, Citymapper was valued at £326M.

Citymapper plans to grow by reaching even more commuters globally, doing so by aiming to cover all the major metropolitan areas in the world. From an economic perspective, however, large numbers of customers do not necessarily equate to more income. In fact, expanding the userbase will require even more funding as to provide the service and enhance the necessary data and technology in these areas - even though the business relies on open data published by organizations such as TfL, it enhances it with data provided by private companies and its own users too, requiring more resources in order to orchestrate and process these data from multiple sources. Citymapper therefore is essentially operating a data factory that patches open data so the end-users may access accurate and reliable information, which generates data sets with copious amounts of diverse yet

reliable data. This opens up potential revenue streams or business opportunities (since an ever-increasing number of consumers can only be beneficial to Citymapper for so much longer before they must begin generating revenue), such as packaging the data and selling it to organizations (demand for traffic data has risen in recent years), but it creates an operational dilemma for an organization that has purposefully positioned itself as an alternative to major tech companies. Nevertheless, Citymapper has stated that it is to launch a new arm offering its routing, data factory and user interface (UI) to other companies, without actually selling individual users' data, (the data sold usually comprises of compiled data on traffic, transport networks and routes).

Likewise, PASS represents another effort to develop an income stream by attempting to turn its London userbase into mobility subscribers. However, PASS doesn't make a profit in the short term and even loses money in some cases. PASS works as a simple prepaid debit card, with Citymapper paying TfL for each trip its customers take up to the point they achieve the standard weekly price cap. Every commuter who reaches the daily Tube price cap of £7.40 a day in zones 1-2, a minimum of five days in a week, will result in Citymapper losing money on these customers that week (since the cost surpasses the Super Pass's £33/week price), which also means that Citymapper could be risking losing a considerable amount of money per user per month should PASS reach a critical mass. Nevertheless, and as previously mentioned, investors recognize the immense data-related value surrounding PASS, since the direct link between ticketing/payment and a mapping service equates to the possibility of obtaining data regarding where commuters step in and out of a certain underground train, as well as how they plan their itinerary, whether they commit to it and where they end their trip, which could explain why Citymapper is paying to discount the fares of commuters as to collect more data.

To become profitable, however, Citymapper plans to extend the service by packaging even more mobility choices, where it will be able to better negotiate prices, until it can provide a package that includes a multitude of transport options such as dock-less bikes, rental vehicles and ride-sharing services. In spite of that, it has been argued that Citymapper might aim to become profitable by utilizing the political-influencing potential that comes with its dominating position within the sector; to build itself a profitable segment, Citymapper may fall on consumers, regulators and the general public, similar to the cases of Uber and Airbnb, which spent their financial resources in order to gain a vast userbase, allowing them to leverage political influence in disputes with city authorities so to establish better conditions for themselves, having redefined policies surrounding their requirements in metropolitan areas including San Francisco, New York and Paris in the process.

3.3.2 WienMobil, *Vienna*

The information presented in the following subsections has been sourced from articles and grey literature such as Audouin and Finger (2019), Cerema (2019), UITP (2019), Urban Transport Group (2019), Upstream Mobility (2021) and Wiener Linien (2021).

3.3.2.1 Overview

Representing one of Vienna's main MaaS schemes, WienMobil stemmed from the SMILE pilot project - an initiative that started in 2012 and ran from 2013 to late 2014, then governed by ÖBB, the Austrian Federal Railway Company, and Wiener Stadtwerke, the City of Vienna Utility Company - and was commercially launched in 2017. It provides information on the majority of Vienna's modes of transportation, as well as a route planner for public transportation, bicycles, car- and bike-sharing, private vehicles, and taxis. For certain supported transport modes, such as the multiple public transport modes, users can access and pay for these as they commute (pay-as-you-go) through the purchase of a range of public transport tickets; for other modes, such as shared mobility and taxi, users are redirected to third-party apps for payment.

3.3.2.2 Technical framework

In contrast to the SMILE project, whose platform and front-end app were developed by Fluidtime and NTT Data, Upstream Mobility was and is responsible for setting up and operating WienMobil's back-end platform which coordinates and connects different MaaS operators to the multiple MSPs (Figure 3.4):

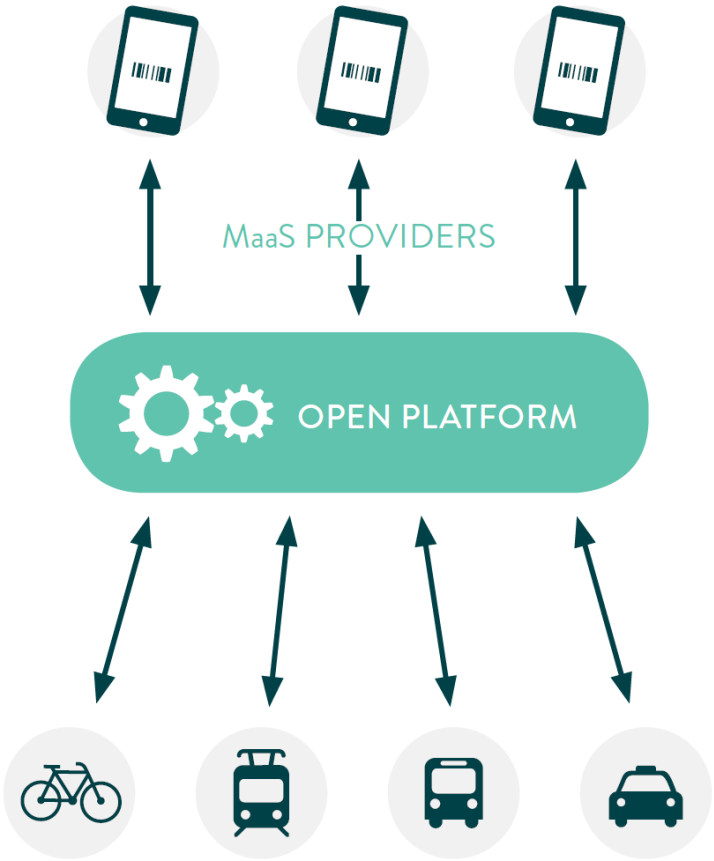

Figure 3.4: Open Back-end Platform model, reproduced from UITP (2019)

More specifically, this platform incorporates data from numerous mobility services, such as schedules, route calculation, booking, ticketing, and pricing, and then allows multiple MaaS operators to utilize it to develop their own MaaS solution. This in turn stimulates competition between, and facilitates the development of, MaaS offerings from different MaaS providers (part of the initial set-up costs are already paid for by the authorities behind the platform), as is the case in Vienna, where WienMobil, as well as MaaS Global's implementation of Whim in Vienna, both operate using this platform, despite the former being led by a private entity and the latter by a PTO. The specific mobility service choices inside the WienMobil app are, however, the product of a long-standing relationship between the Viennese transport network operator Wiener Linien and a number of partner service providers.

Future contracts between Wiener Stadtwerke and potential bike and car-sharing operators will necessitate their services to be incorporated into the open platform, meaning that they can be included in WienMobil as a full service (i.e complete integration). From the operators' point of view, such integration in the platform grants them the approval and/or rebates for the usage of public space, further motivating their participation. Moreover, and given the roles of Upstream and Wiener Linien, for every MSP wishing to partner with WienMobil, a twofold contract must be agreed upon between Upstream Mobility and each mobility operator - for technical integration topics - and Between Wiener Linien (the *de facto* MaaS operator) and each mobility operator.

Other transport modes (taxis, bicycles, car-sharing, etc.) have not yet been fully integrated. However, towns are increasingly putting pressure on free-floating operators to join the platform in return for authorizations or discounts for the use of public space. These mobility operators have every advantage in being incorporated on such platforms if their use is not very ubiquitous; however, should they be firmly established in a given city's mobility offerings, then it might be the case that these want to become mobility platforms themselves and are therefore more reluctant to integrate the platform.

3.3.2.3 Regulatory context

The Austrian Ministry of Transport and Innovation (BMVIT) helped create the path for MaaS to emerge in Austria by developing its 2011 ITS action plan, which intended to develop systems providing transport 'information to individual travelers' and 'booking and invoice services'. However, at a local level, the City of Vienna did not formally participate in the development of SMILE, having done so the ÖBB and the Wiener Stadtwerke instead; it may be argued that the absence of guidance from Austrian public/local authorities, or, more specifically, the lack of a concrete vision from the BMVIT or the City of Vienna on how to incentivize the further collaboration of the two entities, could clarify the reason for the two protagonists deciding to terminate cooperation and follow separate strategies (section 3.3.2.4 explains the paths undertaken by the two entities following the pilot's conclusion).

Upstream's digital platform is constructed according to local policy objectives following rules decided by the public authority, given it is a subsidiary of Wiener Linien and Wiener Stadtwerke. Therefore, and as opposed to the case of Whim in Helsinki, Vienna's MaaS management approach

allows the local authority to better conduct MaaS operators' actions, without compromising the possibility for these operators to develop new services.

3.3.2.4 Economic model

Both the Austrian Federal Railway (ÖBB) and Wiener Stadtwerke led the SMILE pilot, a project financed in more than €3M by both the Climate and Energy Fund and the Austria Research Promotion Agency (FFG) and which cost in total €7.7M (of these €7.7M, a yearly €500,000 were needed for the framework of the SMILE project). The app mainly targeted the Viennese metropolitan region but also included other public transport services in cities such as Graz and Linz. The pilot was finally shut down at the end of 2014, owing to a lack of public financing and disagreements amongst the entities behind it, but such closure led nonetheless to both creating MaaS schemes of their own. The ÖBB founded, in cooperation with a venture fund, a start-up named iMobility, which launched the Wegfinder MaaS app in 2016. The app intended to offer multi-modal information and ticketing services throughout Austria. In parallel, start-up subsidiary Upstream was created in 2015 by the Wiener Stadtwerke. Unlike iMobility, Upstream decided to make use of the expertise acquired during the Smile project by buying the technology from Fluidtime and later developed the WienMobil app in 2017. Conversely, this app had an urban scope, aiming to grant users with multi-modal information and reservation services within Vienna.

Local authorities' financial contributions are determined by their level of involvement and responsibility (that is, whether they or the respective PTO develop an open MaaS platform or application) but can be nonetheless justified by the MaaS' contribution to public mobility policies. Assuming a local authority fully commits to the development of a MaaS scheme, it will firstly need to cover costs related to the acquisition of products provided by third-parties (usually technical providers). Subsequently, the adaption and set-up of said products at a local level, as well as the development of further features (depending on what the local authority intends to achieve with the MaaS and how many players does it aim to partner with) brings upon additional costs. Excluding legal costs related to the contracts between the many MSPs as well as other entities, the financial burden of the local authority can equate to costs between many hundred thousand euros and a million euros.

With WienMobil, where the underlying platform and front-end application is operated by a subsidiary of both a local PTO and a local authority, it is only natural that the financial contribution will help cover the costs relating to the provision and maintenance of the service, communication, customer relationships, transaction fees and so on. In fact, such is the importance of the app that it effectively has replaced the public transport network application (for ticket purchase) and Qando (real-time information and route-planning), thus aiming to become the reference application for virtually all things transport-related in Vienna as to ultimately increase the number of WienMobil users. Indeed, during the first couple of years, Upstream Mobility did require financial support from the City of Vienna, but later achieved economic equilibrium due to its business model and the services and support that it provided for other cities that had plans to develop a MaaS service.

These services ranged from consulting and IT development to providing the digital platform (Figure 3.5) which combines all data and handles all the interfaces with mobility operators, the MaaS operator and the end-user - essentially, Upstream Mobility positioned themselves as a technical provider/service aggregator (section 2.4.1). Furthermore, given that WienMobil originated from the SMILE project, much of the expenses were already previously covered and further adaption expenses are also included in the R&D budget of Wiener Linien.

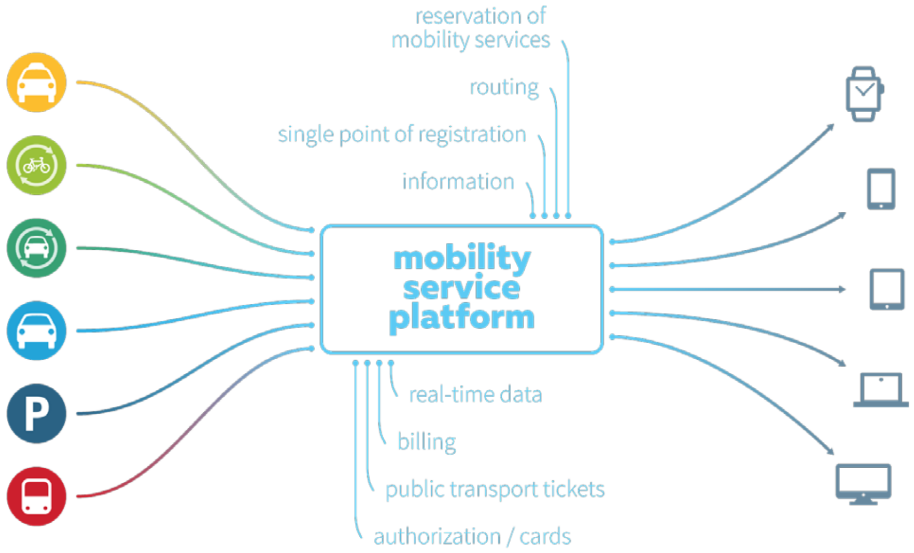

Figure 3.5: Upstream Mobility's mobility service platform and respective features, reproduced from UITP (2019), based on Upstream Mobility (2021)

3.3.3 Whim, *Helsinki*

The information presented in the following subsections has been sourced from articles, research papers and grey literature such as Audouin and Finger (2019), Cerema (2019), UITP (2019), Custódio (2018), Ramboell (2019), MaaS Global (2021), ERTICO (2017) and Zipper (2018).

3.3.3.1 Overview

Whim is Finland's flagship MaaS scheme, operating not merely in several areas worldwide, but also representing the first true MaaS implementation to ever become commercially operational. MaaS Global, the company behind Whim, had its inception in 2016 after the Finnish government aided the creation of MaaS operators following revised legislation and policies regarding Finland's transport and mobility framework. Soon after, in the second half of 2017, the company was able to launch Whim, providing a comprehensive offering of multiple transport options bundled in a front-end mobile application, accessible through subscription packages or pay-as-you-go and spanning the Helsinki metropolitan area, which includes the cities of Helsinki, Vantaa, Espoo and Kauniainen.

3.3.3.2 Technical framework

MaaS Global constructed the data platform which integrates the many application programming interfaces (APIs) - for specific features like booking, information and payment - of the many entities involved, i.e mobility service providers (MSPs), mapping and routing services and payment service providers (PSPs). MaaS Global therefore signs bilateral contracts with these parties directly and the MaaS implementation is developed in an open competitive environment (corresponding to the Commercial Integrator model identified by UITP (2019)), in which investment by the authorities is nominal. Figure 3.6 represents an elementary depiction of the relationship between separate private MaaS operators and MSPs within a city, where the arrows correspond to the agreements established between the aforementioned entities.

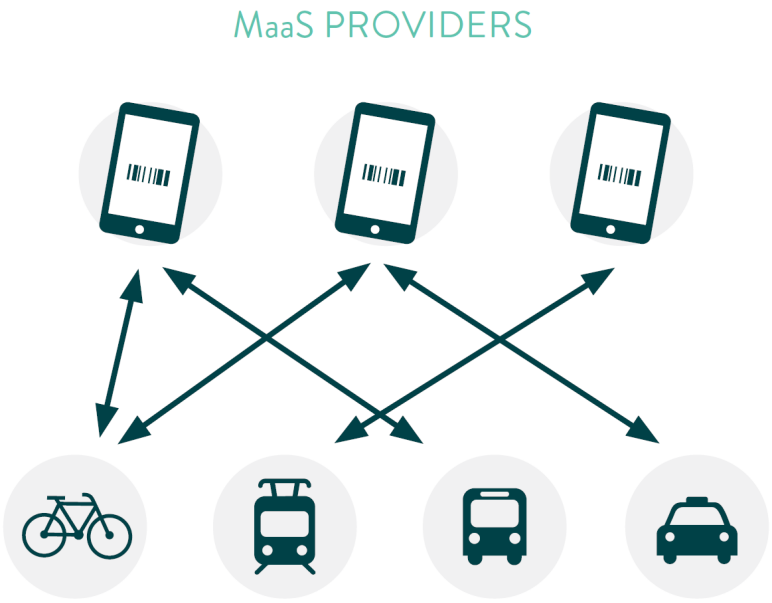

Figure 3.6: Commercial Integrator model, reproduced from UITP (2019)

The strategy towards MaaS of the city of Helsinki and, thus, of MaaS Global is seen as one which stimulates innovation and which attends to consumer needs effectively, by granting private operators more freedom to determine and provide adequate subscriptions, at stake, however, of a mismatch between the goals sought by the MaaS operator and public policies. Otherwise stated, one can argue that the ability to innovate within the service-offer is high, and so is the MaaS operator's capacity to integrate multiple MSPs, as, theoretically, there is no particular affiliation between the private MaaS operator and any transport operator. But favoring more financially attractive partnerships becomes a risk, as there is less of a regulatory pressure to align the mobility offers with fair and non-discriminatory rules. Competition between MaaS operators is, however, a possibility, and would stimulate innovation, should it exist.

MaaS Global considers whether or not to incorporate a mobility service within Whim's MaaS solution in Helsinki mainly based on: 1) the technological requirements for entry into their MaaS, such as the availability of high-quality open data, the openness of the ticketing mechanism, and so

on; 2) the pertinence of the mobility packages offered by the operator; 3) the prospect of reaching an agreement with the operator in question; among other aspects. With regard to public transport and bike sharing services provisioned and implemented by local authorities, MaaS Global signed the standardized terms of use of Helsinki transport authority's (HSL) APIs, whereas with other mobility providers (e.g taxi or car rentals), MaaS Global signs case-by-case arrangements that establish terms of access to the service in question, the respective tariff structure, among other details.

3.3.3.3 Regulatory context

In developing a particular law known as the Finnish Transport Code, Finland's public authorities facilitated the implementation and development of MaaS at a national level. The legislation initially required every Finnish PTO and PTA to open essential data (including, at least, data on routes, stops, timetables, prices, availability and accessibility) in computer-readable format, as well as their single-ticket APIs. This legislation was approved in the spring of 2017, and it was estimated that by 2019, 80% of mobility operators had already opened their data. While having unlimited access to public transportation, Whim subscribers nonetheless had to book one-way tickets whenever they utilized public transport, as HSL initially refused to open the public transportation ticket APIs for seasonal tickets to Maas Global. However, following the second phase of the Finnish Transport Code (voted for in the end of 2017) which required all carriers to open their APIs by the end of 2018, HSL finally changed position in relation to MaaS operators, establishing a dedicated MaaS strategy in spring 2017 and hiring a person in charge of guiding the transport authorities' MaaS-related activities in March 2018, which resulted in the announcement of the newly developed OpenMaaS interface which would add seasonal tickets by November of 2018.

3.3.3.4 Economic model

To make MaaS a reality in Finland, a 700,000 euro funding round was collected in late 2015 from private institutions such as Transdev, Karsan, the Finnish national rail operator VR, Uber, and several other firms, leading to the formation of MaaS Global in June 2016. This proved to be necessary, given that MaaS Global does not receive any government funding for the establishment or operation of Whim. In August 2017, MaaS Global raised €14.5 million in a new round of funding, with new investors including Toyota and Mitsubishi as well as Mitsui Fudosan. Whim's official commercial launch in Helsinki, as well as further global expansion plans, were followed by this fundraising effort.

MaaS Global was responsible for the implementation of Whim's MaaS platform in Finland. However, since MaaS requires the involvement of several (public) entities, this development resulted in local PTOs/PTAs opening up supply data and making it accessible to MaaS operators through APIs (as mentioned in section 3.3.3.3), which cost HSL hundreds of thousands of euros. Regarding private MSPs such as taxis and car rental, Whim provides these with the conditions and exposure to attract new clients and expand. They can also outsource the expenses associated with

such operations i.e customer relations, transaction and billing costs, and so on, to MaaS Global. In exchange, the transport operator will be able to offer its services to the MaaS provider at a discount, where the cost savings are ultimately passed on to the price the consumer pays within the MaaS application. As a result, however, MaaS operators must bear costs associated to not only the operation and preservation of their MaaS infrastructure, but also the incorporation of these several transport operators, emphasizing the value of developing effective business strategies, particularly when achieving an economic balance proves unrealistic due to lack of public subsidy.

In the case of Helsinki, HSL sells tickets for its network to MaaS Global at general public prices, and since MaaS Global does not intend to resell them at a higher price, it makes no profit from selling public transportation tickets, which account for the vast majority of tickets sold by the Whim application. In fact, before the second phase of the Finnish Transport Code, where MaaS Global could only sell single public transport tickets (which weren't being subsidized, as opposed to seasonal tickets), the situation was far less profitable for the company than when it later gained access to seasonal ticket APIs. Any Whim subscriber who booked more than a certain number of single tickets through the Whim app in a month, without booking any taxis or rental cars, would effectively end up causing MaaS Global to lose money. Thus, MaaS Global's approach, in addition to profiting from selling certain mobility services, mainly relies on the success of its subscriptions; ideally, consumers would purchase these mobility service bundles, as opposed to relying on pay-as-you-go, in the hopes that their total consumption, charged by transportation operators, would be less than the amount bought, charged by the MaaS operator. This approach also extends to MaaS Global's plans of expanding its customer base, where such is attempted by increasing the number of offerings and bundles to meet the highest number of subscribers.

3.4 B2B and B2G benchmark

This section follows a similar structure to the previous B2C business-level benchmark (section 3.3), in that it analyzes the upcoming companies according to essentially equivalent criteria. Although numerous B2B and B2G MaaS providers and service aggregators currently operate in Europe, such as Kyyti (Finland), Mobeelity (France), Modalizy (Belgium), XXImo (Netherlands), REACH NOW (Germany), Mobimeo (Germany), Cityway (France), Fluidtime (Germany) and Upstream Mobility (Germany), only two were analyzed due to constraints regarding the maximum number of pages for the document. Nonetheless, Skipr (section 3.4.2) and Trafi (section 3.4.1) both constitute valid, comprehensive examples suitable for review.

3.4.1 Trafi, *Jelbi's MaaS platform provider*

The information presented in the following subsections has been sourced from white papers, namely Trafi (2020a) and Trafi (2020b), as well as articles such as Lewin (2020) and Walmsley (2019).

3.4.1.1 Overview

Trafi, a Lithuanian tech start-up founded in 2013, provides Mobility-as-a-Service solutions to mostly cities and/or governments throughout the world as a method to reduce traffic congestion and re-think mobility. Its current portfolio of clients includes, among other entities, the Berlin Transport Company (BVG), to which it provided the technical platform for the Jelbi MaaS application (included in the feature-level benchmark in Figure 3.2), the Munich Transport Company (MVG), for which it developed the MVGO MaaS scheme and the Swiss Federal Railways (SBB CFF FFS), which relied on Trafi's expertise to develop yumuv, the world's first commercial development of a regional MaaS scheme.

Trafi is positioning itself as the steppingstone between a city authority and the city's goal of providing multi-modal mobility (albeit centered around public transport) to its residents. It advocates that, if a local authority or PTA is able to, together with Trafi, foster the development of a successful MaaS scheme, then, and only then, can it position itself as the Urban Mobility Authority (UMA) as opposed to a PTA, overseeing a holistic network of public and private options.

3.4.1.2 Technical framework

As a technology provider, Trafi supplies the platform on which the MaaS service is built, upholding and allowing for the integration of, and communication between, systems of the many public and private transport providers, as well as the integration behind payments, ticketing systems, user documentation, driver licenses and phone validations, ensuring that they perform as planned. With BVG, Trafi provided its MaaS Suite on which the Jelbi's MaaS scheme was built, meaning that Trafi provided a white-label app that was adjusted to BVG's branding in addition to the back-end system that drives the app and the service - Trafi, however, also offers the possibility for client cities to solely acquire the back-end platform (with no front-end white-label app) that even other MaaS providers can plug into. Users are then able to plan, book and pay for their trips, regardless of the mobility services required for the journey - BVG requested that a deep-level integration should be achieved with all MSPs, so Trafi ensured users could access and pay for their services directly through the BVG Jelbi app, requiring no in-app redirection to any app of a particular MSP. Furthermore, the app is capable of providing real-time public transport information and shared mobility vehicle location by collecting and optimizing incoming static and real-time mobility data, as well as a price and cost comparison feature for each possible trip - however, user registration is required (although the user is able to login into Jelbi with their BVG account).

BVG manages the city's U-Bahn underground railway, tram, bus, replacement services and ferry networks, and thus plays a distinct yet crucial role within the development and provision of the Jelbi service. As the owner and leader of the Jelbi project, BVG not only managed the Jelbi project, defining the strategy for what the scheme was supposed to become, but was and is also responsible for managing the relationship and contracts with the many MSPs. However, the payments for the services of these MSPs booked through the Jelbi app are managed directly through the integrated Payment Service Provider (PSP), in this case, LogPay. The PSP therefore

charges money from users and directly transfers it to the MSPs, in a process through which neither Trafi nor the BVG intervene.

3.4.1.3 Economic model

The shift in Trafi's strategy is perhaps the most notable evidence of adaptation on the tech start-up's behalf. Indeed, Trafi first began as a mapping service and route-planner, providing its app to several locations worldwide. However, the company struggled to define its business model and thus to generate income, which is why it began shifting towards providing the technology it had developed for the app to other players; the company kept operating its B2C application, but began working together with cities to implement MaaS, as well as licensing its proprietary software (e.g its multi-modal routing algorithm) and providing services (e.g retrieving open public transport data and enhancing it) to companies like Google, Apple, Lyft and Gojek. Ever since the shift in business model, Trafi was able to achieve considerable growth.

The concrete monetary worth of the white-labeled app provided by Trafi is uncertain; as there is no agreement to price, the investment in integrated mobility cannot be quantified. The partnership between BVG and Trafi, however, entails a call option; should the former want to maintain its relationship with the latter, it must purchase Trafi's technology and continuous assistance, which means (according to the terms of the deal) BVG will instantly possess the anonymous data collected from Jelbi users regarding how commuters travel about Berlin.

Both BVG and Trafi collaborated in what could be argued to be a sort of urban display, whose goal is to demonstrate that cities can be as responsive and adaptable to the market as the private sector, and that Trafi is the key enabler for such a feat. Accordingly, Trafi received an increasing number of inbound requests from city leaders and authorities following Jelbi's launch in 2019 - according to Trafi's CEO Martynas Gudonavičius, the company is in negotiation with multiple cities in Europe, including five in France, and is yet to announce partnerships with "very well-known names" in the tech realm. The COVID-19 pandemic and consequent lockdown procedures did in fact pose an opportunity for urban transport planners to reevaluate the safe resurgence of transport and mobility, while aiming for a lesser dependence on private automobiles. In parallel, the Jelbi app became even more popular than it ever had been prior to the COVID-19 pandemic, which, combined with the fact that approximately 50% of journeys are made on sustainable single-occupancy vehicles such as bikes and scooters, increases the scheme's appeal to other European city authorities, which ultimately aim at improving their cities' mobility context without depending excessively on personal automobiles.

The increased activity of the tech start-up further stimulated fundraising - in 2020, Trafi raised a Series B financing round headed by the Japanese corporations Sumitomo and Aioi Nissay Dowa Insurance, with Octopus and the European Bank for Reconstruction and Development (EBRD) also participating, totaling approximately double of the $14M of funding Trafi had obtained until August of the same year.

3.4.2 Skipr, *a B2B MaaS provider*

The information presented in the following subsections has been sourced from articles namely Skipr (2020), Zipper (2020), FLEET.be (2020), Wauters (2020), Silicon Canals (2020), MAAS-Alliance (2020), as well as Belgian legislation on mobility (Banque-Carrefour de la législation, 2019).

3.4.2.1 Overview

Skipr is a Belgian MaaS startup founded in 2018 by Mathieu de Lophem and start-up incubator Lab Box. It provides client companies and their employees, as well as self-employed businesses, with services such as route-planning, booking and payment, in the form of an app which connects them to multiple transport options from local public and private transportation, to other MSPs like Uber, Bird, Dott and Lime. Alongside the app, Skipr includes a dedicated debit Mastercard to pay for and access mobility services authorized by the client company across Europe, including parking or rental cars. Furthermore, the client company's HR manager is provided access to a web-based dashboard or an interface integrated within the client company's systems, which allows for the management of not only employees' mobility budgets and the company's mobility policies, but also reporting regulation compliance (i.e CO2 and tax reports) and other HR tool connections.

3.4.2.2 Legal and technical framework

Skipr's mobility solutions target the 'company car' directly and leverage on the apparent trends toward more sustainable and comprehensive alternatives. Nevertheless, more than 10% of Belgium's 5.7M vehicles were registered as company cars as of 2016; after all, the company car is an established tax-protected employee benefit in many European countries. However, mobility regulations and corporate practices in Europe are evolving as a result of a rising need for greater variety and versatility in mobility in order to relieve stress on their road systems. For instance, the Belgian Law on the Mobility Budget, passed in 2019, enables employers to set up a mobility budget within their companies, aiming at fostering and promoting environmentally-friendly cars (full-electric vehicles or vehicles with CO2 emissions of under 95 g/km from 2021 onward), soft mobility (purchase, rental, leasing, maintenance and legally required equipment), cycles and motorcycles, public transport subscriptions - for the distance from home to work and on behalf of the worker - and tickets (public transport tickets in Belgium or in the European Economic Area), organized public transport, carpooling, taxi services, chauffeur-driven car rental services and rental of self-driving vehicles (maximum 30 days per year). These mobility budgets provide tax breaks for individuals who commute through these aforementioned alternative modes, in an effort to disassociate the active population off corporate vehicles; as such, Skipr is able to provide tax-protected mobility.

The specific mobility offerings included in Skipr's solution in Belgium are those of SNCB (National Railway Company of Belgium), STIB (Brussels Intercommunal Transport Company), the

Flemish transport company De Lijn, OTW-TEC (Transport Operator of Wallonia - Public Transport), Bird, Uber, Poppy, Billy and Dott. The application allows for the combination and use of these several modes of transport through an in-house inter-modal routing algorithm. Furthermore, the payment is unified, meaning Skipr provides a single payment channel through which every service is accessible, which also entails a single associated invoice, potentially reducing administrative costs incurred by the client company's fleet managers and workers. However, employees may also pay for services using their own budgets or the Skipr debit Mastercard, allowing for further access to mobility within Europe. Each journey made by the client's staff is supplied to Skipr's data center for the purpose of data evaluation and of obtaining valuable insights, which in turn results in improved trips and staff incentives, as well as greater visibility on the overall environmental effects.

3.4.2.3 Economic model

Skipr's client portfolio in Belgium includes Accenture, Ogilvy, L'Oréal, Carrefour, Alan, Luminus and Positive Thinking Company. Moreover, Skipr stands before the opportunity to acquire new clients in markets like Germany and France, where B2B MaaS solutions might be particularly attractive as, in these countries, company cars are a well-established corporate incentive as well. The start-up's early success has caught the attention of investors, and has aided Skipr in capitalizing on this market-expansion opportunity; in 2020, the company announced it had secured €7M in Series A funding, led by Belgian bank Belfius and existing investor Lab Box, in order to support the development of its product offering and venture into new markets, starting with France.

According to de Lophem, Skipr provides "the right product at the right time. Whilst B2C MaaS players are often still looking for a business model, our B2B solution has been generating revenue from day one and perfectly fits the current changing legal frameworks in Europe". Skipr will nonetheless compete with other B2B MaaS operators such as REACH NOW (part of the mobility joint-venture between the BMW Group and Daimler), Modalizy and XXImo. Furthermore, Skipr's CEO is confident about the long-term popularity of corporate MaaS, having stated that "60% of people who are new to a company – people who do not yet have a company car – opt for the mobility budget. About 20% of company car drivers hand over their car. So it will take time, but I do see a bright future."

Chapter 4

Framework for the analysis of MaaS implementation approaches

Venturing into a new sector, industry or market requires, among crucial tasks such as defining and analyzing the market at hand, an assessment of feasible and practicable approaches. In particular, defining the target market is paramount, as it can prove essential for the long-term feasibility of a service. Accordingly, this chapter builds upon the literature review and the benchmark of MaaS, where its characteristics, as well as a selection of European MaaS schemes, were studied, and proposes a framework for the analysis and comparison of business, general consumer and government-facing approaches for the implementation of MaaS (Figure 4.1).

The methodology behind the construction of the framework consisted in, initially, identifying the three overarching approaches to be compared. These were the product of the MaaS business perspective analysis carried out in the literature review, as well as the benchmarks conducted in the previous chapter, and differ with respect to both the target market and the role of the MaaS implementer within the MaaS ecosystem. As such, the business-to-consumer (B2C) and business-to-business (B2B) approaches both lie at the MaaS operator/provider level, since it is the operator's foremost responsibility to deliver the service to the customers, whether these represent businesses or a particular city's commuters; the B2C approach, however, has been further boiled down into private and public sector initiatives. The business-to-government (B2G) strategy, in turn, corresponds to the technical provider/service aggregator level, as it is precisely the public MaaS operators - i.e local authorities, public transport authorities (PTAs) or operators (PTOs) - that the B2G technical providers target, by providing the platform for their B2C urban MaaS schemes.

Subsequently, criteria against which each strategy is reviewed are proposed. These stem from: 1) Osterwalder's Business Model Canvas (figure 2.6), which is composed of nine building blocks, three of which are included in the framework - 'Partners', 'Cost structure' and 'Revenue stream(s)' - and two of which were merged into one - 'Customer Relationships' and 'Channels' combined to form 'Exposure and marketing' - and 2) the business-level benchmark developed in Chapter 3, where criteria such as 'Regulatory framework' and 'Data/APIs' were adapted from the 'Regulatory context' and 'Technical framework' analyses. The remaining criteria were identified as a result of

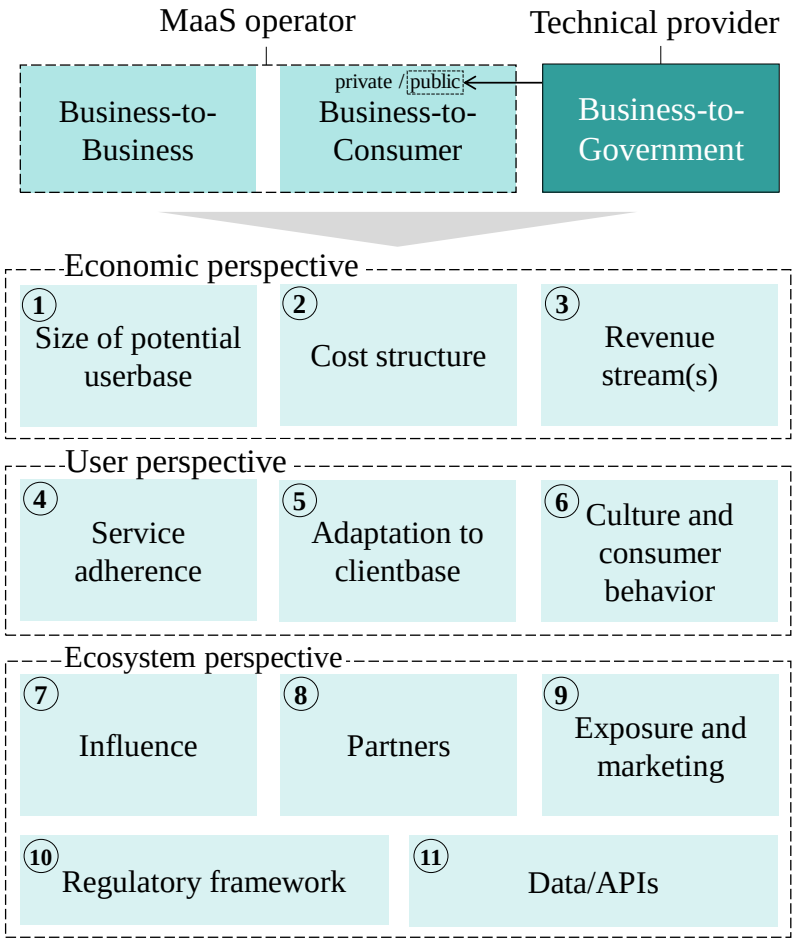

Figure 4.1: Framework for the analysis and comparison of business, consumer and government-facing MaaS implementation strategies

the overall development of both the literature review and the European MaaS benchmark.

In total, 11 criteria were identified. The framework presents these in numerical order under the customer-facing business strategies and further groups these into three perspectives - Economic, User and Ecosystem.

These perspectives aim to aggregate the characteristics presented in the literature review (section 2.2) into more comprehensive clusters; 'Payment options' (section 2.2.3) is considered homologous to 'Revenue streams', and joins with 'Cost structure' and 'Size of potential userbase' as to form the 'Economic perspective'. Similarly, 'ICT integration through a digital application' (section 2.2.2) relates to the 'User perspective', as it is the user (i.e company or an individual) who interacts with the front-end MaaS platform; as such, this cluster addresses crucial aspects behind the adherence levels of the customers to such a digital application by covering the extent to which the MaaS operator is able to adapt to its client base, as well as the present culture and ongoing consumer behavior with regard to mobility as a whole. Lastly, 'Transport options' (section 2.2.1) is incorporated in the 'Ecosystem perspective', as the many MSPs in fact represent the main key actors and partners within the core MaaS ecosystem (Kamargianni and Matyas, 2017;

Polydoropoulou et al., 2020). They also greatly determine whether or not the MaaS operator is able to influence the regulatory framework in favor of MaaS, particularly in the case of public transport service providers, which significantly reflect the courses of action led by the local or national authorities responsible for defining the transport and mobility policies.

In summary, the proposed framework serves as a comprehensive tool to analyze the aforementioned approaches against a diverse and grounded set of criteria. Accordingly, the following subsections will now dive into each criterion, where the ramifications and implications of the overarching MaaS approaches are analyzed through different lenses, while aggregating key points from the previous chapter's analyzed MaaS schemes and players by placing the crucial takeaways and data in a more comparative and delineated context.

4.1 Size of potential userbase

The first step of the framework corresponds to the scale of a particular MaaS scheme. Whereas a B2C MaaS operator inherently embarks on a strategy of aiming for the general urban resident, visitor and tourist, a B2B MaaS operator will target companies, whether these are large firms or self-employed businesses. Consequently, the former will potentially reach a mass of consumers larger than the latter, since an urban MaaS scheme is essentially made available to anyone with a smartphone within a particular city. However, although Figures 3.2 and 3.3 show how the 10 reviewed B2C MaaS schemes will generally sustain a userbase of between 20,000 and 100,000 users within a particular city, fast-growing B2B MaaS startups such as Skipr already manage multi-company client portfolios (section 3.4.2.3). On the other hand, such growth inescapably calls for further investment; in 2020, the B2B MaaS operator Radiuz (now merged with XXImo, operating under its name) expanded its service into the B2C space by providing on-demand mobility access for individual users, but had to outsource its billing processes to Zuora (a cloud-based subscription management platform provider) since it was not able to scale its homegrown billing platform quickly enough to support not only a larger userbase, but also the high volumes of usage-based and individual billing, in addition to complex discounts.

Concurrently, B2G technical providers do, in fact, offer a service to local or national authorities wishing to provide MaaS, but nonetheless aggregate the back-end and/or front-end platforms for said MaaS schemes, meaning that the service reaches the same userbase as in the case of the B2C MaaS operator. Furthermore, an urban userbase is heterogeneous by nature (different commutes, schedules, travel habits, and multiple other factors), which means that the technical provider must cope with the high degree of complexity in integrating different services and managing the ever-changing real-time demand for data. This, among other reasons explored in the further sections, is why a B2C MaaS operator is naturally inclined to resort to the expertise of a B2G service aggregator such as Trafi, Cityway or Upstream Mobility - the scope of activities of each player is reduced, and greater efficiency in the provision of the MaaS service can be achieved.

Large private B2C MaaS operators, namely Whim (in Helsinki) and Citymapper, choose nonetheless to develop the technology in-house, recognizing the immense value behind creating digital platforms with (data on) huge userbases. Furthermore, a large userbase aids MaaS operators and technical providers in developing more consistent and customized mobility services derived from the large quantities of mobility data. In sum, a larger potential userbase generally equates to exponentially higher costs at all fronts (see section 3.3.1.4), but proves to be a necessary approach in the case of the B2C strategy, should the MaaS operator aim to try and profit off of an inherently low-margin business model such as a pay-as-you-go tariff, or to attract as much potential subscribers to mobility packages (see section 4.3), as is the case with MaaS Global.

4.2 Cost structure

As seen in the last subsection, the general costs of implementing MaaS are proportional to the scale of the MaaS scheme. This next step of the framework aims to address, however, the costs specifically at the operational and investment levels. Indeed, regardless of the opted consumer-facing strategy, MaaS will imply investment costs related to the initial development of the MaaS scheme - for instance, design and development of both the platform and the smartphone app, as well as brand creation - and operational costs for operating and maintaining the system (Polydoropoulou et al., 2020).

The investment costs are usually incurred by the B2B and B2C MaaS operator (public or private sector), whether implemented in-house or outsourced to a B2G or B2B technical provider, or might be shared in the case of a 50:50 MaaS operator and technical provider partnership. Concerning Jelbi in Berlin, the *de facto* MaaS operator BVG purchased Trafi's services (i.e the platform, necessary technology and further assistance), whereas in Vienna, both Upstream Mobility and WienMobil belong to the same mother entities, and thus the public sector incurs the totality of the costs. However, such public financial contributions can be justified on a policy level by the MaaS schemes' contribution to sustainable mobility efforts. Nonetheless, and according to Cerema (2019), the financial burden of a local authority wishing to implement a B2C MaaS scheme, regarding the set-up of the platform and development of scheme-specific features, and excluding legal costs related to contracts between MSPs and other entities, can reach anywhere between many hundred thousand to a million euros.

General operational costs incurred by MaaS operators include both fixed and variable costs; the former relate to, for instance, the amortization of the investment cost, marketing costs, maintenance costs for the website, app and platform, legal-related costs and data security and privacy related costs, and the latter include MaaS service provision costs, customer service and support, and personnel and insurance costs (Polydoropoulou et al., 2020). Private MaaS operators greatly rely on funding rounds to kick-start their service and overcome these large initial investment costs, as well as to expand their service, since their MaaS schemes lack public subsidization for the most part. This was the case with B2C operators MaaS Global (see section 3.3.3.4) and Citymapper (section 3.3.1.4). B2B MaaS operator Skipr, on the other hand, had proven its business model by

the time it received its Series A funding, thus using it to expand its service and improve its product offering.

Nevertheless, in the case of MaaS Global, developing the Whim service did in fact result in Helsinki's PTA (HSL) spending hundreds of thousands of euros in making its supply data accessible to MaaS operators such as MaaS Global. Regulation in Finland had made it nonetheless mandatory for every Finnish transport provider to open essential data; in a situation where that is not the case, a lot more resistance is expected from PTAs and PTOs to utilize capital for opening up data. Private MSPs, on the other hand, stand before the opportunity to attract a new customer base while outsourcing expenses (i.e customer relations, transaction and billing costs) to the MaaS operator, in exchange for the provision of services to the MaaS operator at a discount. The MaaS operator will nonetheless bear costs related to the operation and preservation of the MaaS infrastructure, as mentioned above, but also the inclusion of these MSPs.

B2B MaaS operators, however, are carving a niche as the ideal replacement for the standard company-car, by providing a service which, in theory, can prove to save costs on the client company's side by replacing leasing costs, cabs and parking costs, with a MaaS platform and an associated payment card - as to pay for journeys directly without advancing the costs (Capgemini Invent, 2020). Furthermore, covering investment costs is easier in the B2B MaaS operator strategy; the client base is entirely composed of paying customer companies operating on bigger margins, whereas B2C MaaS operators must try to convert their userbase into tangible revenue by either: 1) attempting to convince users into subscribing for mobility packages within their free app, or 2) relying on the pay-as-you-go tariff which depends on substantially slim margins (section 4.3 will address revenue streams in more detail).

Furthermore, it is precisely with the B2G technical provider strategy that Viennese authorities were able to achieve economic equilibrium at the MaaS platform level; indeed, during the initial years, Upstream Mobility did require financial support from the City of Vienna, but later achieved an economic balance due to its business model and the services and support (consulting, IT development, and so on) that it provided for other cities that had plans to develop a MaaS service, further stressing the economic importance of the B2G platform provider role within the general MaaS ecosystem.

4.3 Revenue stream(s)

The Revenue stream(s) correspond to the last criterion of the framework's Economic perspective. This step aims to dive into the revenue models of B2B and B2C MaaS operators, which, in simplistic terms, stems from the provision of MaaS to customers, and of B2G technical providers, which sell their expertise to MaaS operators by developing the necessary technical solutions required for the operation of their MaaS schemes.

At the B2C MaaS operator level - referring to (and further exploring) section 2.2.3 - payment options on the user's side usually consist of either 1) pay-as-you-go, where end-users pay as they utilize the services from the many MSPs, or 2) subscriptions for an agreed time period, where

end-users pay a weekly, monthly or annual fee and in turn are entitled to a package of transport services from multiple MSPs. Polydoropoulou et al. (2020) highlight further less-common revenue streams such as advertisement and commissions from non-MSPs (for instance, through contracts conducted with event partners).

Pay-as-you-go is the more ubiquitous model, as it requires less of a behavioral change, both on the MaaS operator and consumer's side (the user simply pays for the services utilized, and the MaaS operator charges for each trip). The challenge with this model is the very narrow margins by which the many MSPs operate, meaning that these are highly opposed to agree upon paying considerable commission rates to the MaaS operator, given their already tenuous economic balance (the MSPs would solely be able to pay small commissions, meaning that MaaS operator profitability could only be achieved at a considerable scale). More concretely; in order to keep the final price attractive to users (i.e equivalent to the price users would have paid had they bought the trip(s) with separate apps/services), the MaaS operator must make up for the costs (section 4.2) it cannot bear - due to the non-existing end-price difference at the customer-level - with commissions charged to the many MSPs. Otherwise, the margin would be applied directly on the general ticket and trip prices, at the elevated risk of discouraging users from adhering to the MaaS service.

Although having been implemented previously, MaaS subscriptions were first commercially available with Whim in Helsinki. MaaS Global realized it couldn't make a profit from selling public transport tickets (in some cases it would actually lose money, in a situation similar to Citymapper with its PASS service - sections 3.3.3.4 and 3.3.1.4), which was indubitably the most popular transport service within the MaaS scheme (Ramboell, 2019), and thus shifted its B2C strategy to selling mobility packages with monthly billing. The core value of these subscriptions lies in 1) the many different mobility services it includes in a package; 2) the deep integration of the available MSPs within these packages and 3) the non-sporadic nature inherent to subscriptions (constant fee for a given time period). The most profitable subscription available in Whim is, theoretically, the most expensive one, where it is able to increase its profit margin considerably. However, MaaS Global has difficulties in converting customers to this premium subscription, which is priced at €699/month, equivalent to the general monthly cost of car ownership, since European car owners not only doubt a mobility subscription can truly be as flexible as owning a car, but also underestimate, on average, the true costs of car ownership by as much as 50% (Capgemini Invent, 2020).

The subscription-based revenue strategy entails a further risk; ideally, the total consumption of services, charged by transportation operators, must be less than the amount bought, charged by the MaaS operator. However, this is not always the case; the Citymapper PASS service doesn't make a profit in the short term and even loses money in some cases. This is because Citymapper pays TfL for each trip its customers take up to the point they achieve the standard weekly price cap. Thus, every customer who reaches the daily London Tube price limit of £7.40 a day in zones 1-2, a minimum of five days in a week, will equate to a loss of money on Citymapper's behalf for those customers that week (since the cost surpasses the base package's price of £33/week), which also translates to an even greater monthly potential loss should PASS reach a critical mass. Nonetheless, both Citymapper and MaaS Global aim to turn their services more profitable by

packaging even more mobility choices, where they will be able to better negotiate prices up to they point they are able to provide packages that include a myriad of transport options.

At the B2B MaaS operator level, the revenue model is generally able to reach profitability at a sooner stage. B2B operators such as XXImo and Skipr provide an internal MaaS solution to companies' employees, granting these companies with mobility budgets that nudge the employees to more sustainable mobility choices, with added value originating from features such as carbon tracking for measuring the contribution of mobility towards their carbon footprint, as well as improved expense tracking of urban and regional mobility of their employees (Cohen, 2020). On the client companies' end, opting for a MaaS mobility budget might reduce costs by shifting from owned and managed corporate fleets towards the use of interconnected mobility services (Cohen, 2020). Furthermore, European B2B operators can take advantage of the opportunity to acquire new clients in markets like Germany and France, where B2B MaaS solutions might be particularly attractive as, in these countries, company cars are a well-established corporate incentive as well (see section 3.4.2.3). The case of Belgium stands out as a prime example of how mobility regulations and corporate practices in Europe are evolving as a means to relieve congestion; the Law on the Mobility Budget, passed in 2019, enables employers to set up a tax-protected mobility budget within their companies, as to promote environmentally-friendly mobility instead of traditional vehicle leasing. Such laws consequently enabled B2B operators such as Skipr and XXImo to further increase the value of their MaaS offerings (section 3.4.2.2).

B2G technical providers and service aggregators like Trafi and Kyyti obtain their revenue streams by proposing white label and customizable solution offers to PTOs and PTAs looking for more affordable and easily deployable MaaS solutions (Capgemini Invent, 2020). Perhaps what is most notable is the shift in Trafi's strategy from a B2C player to a B2G technical provider; it did so because it encountered severe difficulties in defining a business model as a B2C mapping and route-planning service. It then began shifting towards providing the technology it had developed for the app to other players, working together with cities to implement MaaS, as well as licensing its proprietary software and providing services to large technology companies (section 3.4.1.3), being able to achieve a remarkable growth ever since. Upstream Mobility, as a public B2G service aggregator, was initially funded by Viennese local authorities in order to develop WienMobil's back-end platform, but, as mentioned in the previous section, was able to achieve economic equilibrium due to further revenue streams obtained from the provision of MaaS services and support to other cities wishing to implement a MaaS scheme.

Both public and private sector MaaS initiatives may receive funding for the initial development and/or further expansion of the respective MaaS service, albeit through distinct means. Furthermore, while it is crucial for private MaaS operators to achieve profitability at some later stage, it must be noted that public MaaS operators might operate at a loss, since, and depending on the legal framework of each city/region, public subsidization might represent a valid revenue stream; indeed, social benefits such as environmental benefits, public health, reduction of congestion, social equity, and so forth, constitute valid motives to persist with the subsidization, should the MaaS scheme in fact aid in such feats. Private funding, on the other hand, has helped sustain Citymap-

per's business; indeed, Citymapper Limited increased its income in the past years, but it is still losing money (section 3.3.1.4). Nevertheless, investors remain confident in the company (having reached 50M users in its global mapping application in 2021) as well as in the PASS service, since they recognize the immense data-related value surrounding the direct link between ticketing/payment and a mapping service. The success of companies such as MaaS Global and Skipr has also led to healthy funding rounds, enabling these to expand and develop their service offer.

4.4 Service adherence

The adherence to the MaaS service represents the first step within the framework's User perspective and is of paramount importance as it guarantees the success of the MaaS scheme. In general terms, however, multi-sided platforms such as MaaS (i.e platforms which mediate transactions across multiple customer groups or 'sides') face particular user-adherence related challenges, namely the chicken and egg problem (getting both the seller and the buyer sides to utilize the platform) as well as gaining a critical mass of users on both sides, in the right proportions, as to guarantee acceptable added-value and sustainable growth (Jittrapirom et al., 2017). On the user-side, however, significant data exists to support the attractiveness of MaaS as a means to shift commuters out of their personal cars; trials in Sweden and in Greater Manchester revealed how, in the former, private car use reduced by 50%, and in the latter, 82% of participants interviewed wanted MaaS back six months following the trial, in addition to one third of car owners wanting to give up their vehicle (UITP, 2019). Indeed, Europe is considered an ideal environment for the adherence to MaaS platforms: developed countries with comparatively wealthy citizens, cities with strong local political power, developed public transport and an ever-growing sustainable mindset among urbanites in the search for reasonable alternatives to car ownership (Capgemini Invent, 2020).

Nevertheless, and in practical terms, MaaS providers have found minimal momentum amongst urbanites, including in favorable markets. Local law in Antwerp, for example, mandates mobility providers to connect with at least two MaaS platforms, yet just 3% of transit tickets purchased on smartphones in the surrounding area of Flanders are purchased through a MaaS app (Zipper, 2020). In Helsinki, over a year after the launch of Whim, approximately 70,000 people - or 6% of the population of the Helsinki region in which Whim offers are available - had an active Whim account (Cerema, 2019); such a low percentage of user-adherence at the time might have been explained by research from Liljamo et al. (2020), showing that most individuals in Finland would only adhere to a MaaS subscription if it delivered more than a 30% reduction on their existing mobility costs, which proves to be a significant hurdle, particularly when most vehicle owners underestimate how much they spend running and operating their cars.

Ease of use and reliability of the front-end platforms play a substantial role as well; public B2C MaaS schemes such as WienMobil and Mein GVH both have 2.9 and 2.7 out of 5 star ratings on the Google Play store (as of June 2021), further re-enforcing the general perception of PTAs developing perhaps more non intuitive applications. For comparison, Vienna's version of Whim,

directly competing with WienMobil, boasts a 4.5 rating in the Apple App Store, albeit with much fewer downloads.

Yet publicly led B2C MaaS apps such as Jelbi, with 100,000+ downloads, currently rest at a 4.5 rating as well. In fact, such is the attractiveness of Trafi's development of the Jelbi app that the company is beginning to compete with established companies such as Siemens Mobility GmbH that also provide software to cities (Lewin, 2020). The strategy of pairing a private B2G technical provider with a PTA or PTO in order to develop a MaaS scheme does make sense from a concentration-of-efforts point of view, which will be further explored in the upcoming sections. Nevertheless, convincing cities (as a B2G technical provider) as opposed to urbanites (as a B2C MaaS operator) to adhere to MaaS, entails a more comprehensive approach, as transit agencies might be skeptical of investing in such initiatives; Trafi's CEO Martynas Gudonavičius stated how the company adopted an educational approach with cities, explaining to the respective authorities how a MaaS scheme could bring value to citizens and how it was important for the city to lead such a scheme, as opposed to a mobility giant like Uber or Google, as the city is "the only agnostic and independent operator who can combine all modes of transportation without being biased." (Lewin, 2020). Nevertheless, and as mentioned in the previous section, the Jelbi MaaS scheme proved to be an effective display of an attractive partnership, and led to the further adherence of multiple cities to the B2G solution provided by Trafi, including Munich, Zurich, Basel, and Bern, as well as other cities yet to be announced.

On the corporate side of MaaS, adherence to B2B MaaS solutions is generally better ensured, as 1) the MaaS solutions are usually tailor-made to some degree for the client companies, 2) these constitute a tax-protected employee benefit, and 3) commuting represents one of the greatest use-cases for MaaS (Jittrapirom et al., 2020; Loubser et al., 2020). Indeed, in 2018, European workers spent 1 hour and 24 minutes a day commuting according to SD Worx, a leading European player in payroll and HR (Capgemini Invent, 2020). Additionally, more and more European nations are calling on companies to engage actively in lowering their carbon footprint, which may result in financial incentives towards implementing corporate MaaS (as opposed to company cars), further stimulating adherence to B2B MaaS solutions.

4.5 Adaptation to client base

The analysis of this particular criterion complements the previous step by providing a more high-level perspective on the implications of adapting to the particular end-users, with regard to the respective areas of operation.

Whereas B2C MaaS schemes generally follow a one-size-fits-all strategy, mainly differing within the few subscription packages they offer, B2B MaaS solutions must invest in a company-tailored solution, as to fit the mobility needs of the particular client. However, international B2C MaaS companies like MaaS Global must tailor the implementation to the particularities of each city it operates in, further adding to the complexity in adaptation. Nevertheless, and due to its private nature, it is in MaaS Global's interest to adapt to multiple client bases, since it can expand

its business and acquire new customers. B2C MaaS schemes led by public authorities, on the other hand, find it challenging to connect with other cities, since it is generally out of their scope to develop services that could otherwise be developed by other local authorities instead (Kamargianni and Matyas, 2017). Nevertheless, publicly owned B2G technical providers such as Upstream Mobility have expanded their business to other cities, given their B2G strategy rather than B2C (i.e, their role within the ecosystem as technical providers instead of urban MaaS operators). However, these B2G technical providers, both private and public, possibly face the biggest challenges with regard to client base adaptation, since a myriad of factors emerge that positively or negatively influence the ease of implementation of a given platform in a city, namely at the regulatory, partnership and data-availability levels.

4.6 Culture and consumer behavior

The prevalent car-centric culture represents the biggest challenge within the criteria of the User perspective. Indeed, the car is among the most prevalent vehicles in the world, having shaped the entire global transport system with its advent. Its ubiquity clarifies the lengths commuters are willing to go in order to keep their cars, and consequently, their mobility; in Europe, such efforts equate to an average monthly expenditure of driving and owning a car varying between €491 in Hungary and €926 in Switzerland (LeasePlan Corporation N.V., 2020). Furthermore, car ownership and leasing, as well as season tickets, all cause behavioral lock-in due to the upfront cost involved and the enticement of 'spending now to save later' (Lyons et al., 2019). The ownership culture and prevailing consumer behavior with regard to mobility is, therefore, widely considered as one of the biggest challenges of MaaS (Mulley, 2017). Accordingly, in a Norwegian study undertaken by PA Consulting (2019), it was found that both the economic benefits and other non-economic advantages of MaaS, like convenience and reduced journey times, will need to be clear and substantial enough to ultimately incentivize people out of their cars, a feat which represents the end-goal for B2B and B2C MaaS operators alike, in addition to B2G technical providers.

Most European local governments and authorities also share this point of view to some extent within their mobility policy goals, particularly in heavily populated cities with a clear excess of vehicles. Furthermore, as explored in the previous sections, employers, too, play a significant role in the shift from the privately owned car to more sustainable transport, by offering, in many cases, the public transport passes to their staff if they choose to commute by bus, metro or train, resulting in a tax reduction in the commuting cost for the employers/employees. However, should an employee of a company that doesn't offer MaaS/mobility budgets opt for MaaS instead of a public transport pass, and the employee might not be entitled to the same subsidy or tax reduction (Li and Voege, 2017); only when MaaS is identified by most local authorities as a form of sustainable mobility with the same policy for government subsidy/tax reduction as other public transport modes, can B2C MaaS schemes fully expand their use-case to all fronts including corporate.

For now, the current business mobility culture generally acts in favor of the company car, with some previously mentioned exceptions such as the case of Belgium (section 4.3). Nevertheless,

MaaS, be it B2C or B2B, offers the prospect of aiding in the mitigation of the car ownership culture and the shift consumer behavior through 1) commitment to periodic (usually monthly) mobility service plans, and 2) the ability to change service plans or to change between modes within a given plan (Lyons et al., 2019).

4.7 Influence

The framework's Ecosystem perspective begins with the Influence step, where the ability of certain players to persuade others to embrace MaaS is assessed.

Within the urban transport industry, it is the public sector that typically holds the strongest stance, although, at a European level, challenges are arising from the likes of transport policies that increase open competition, as well as pressure from privately-run newcomers. MaaS follows a similar logic as it ideally integrates both the public and private offerings within a city; furthermore, the level of influence a MaaS operator has over the wider mobility context greatly depends on the governance model behind the scheme itself. In particular, private and public sector-led MaaS schemes greatly differ with regard to the approach they must have in order to influence other parties in the direction of MaaS.

In the case where the PTA is the B2C MaaS provider, it is easier to secure that all the public transport modes of the city will not only be offered via such a service, but also include key MaaS-enabling features such as sensors on their fleet and ticketing systems that accept smartphone reading. In addition, due to the fact that, in most cities, the PTA is the entity in charge of authorizing or procuring all the other MPSs, it could also be more feasible to secure their participation in the MaaS service (Kamargianni and Matyas, 2017).

The private sector, on the other hand, is thought to be better equipped to offer innovative and customer-focused services rapidly and without governmental limitations or intervention, along with a higher rate of consumer adoption (PA Consulting, 2019). However, influencing public transportation providers to join the MaaS scheme might take longer; the city's PTAs might fear the loss of their status as the city's transportation integrator and supplier (Kamargianni and Matyas, 2017). Additionally, influencing itself might not be enough; in such situations, only a regulatory change, as seen in the case of Finland (where a national law essentially made it mandatory for HSL to open its data to MaaS operators), proves to be the true enabler for MaaS.

From an influencing potential standpoint, the B2G approach entails that it is in the technical provider's interest to cooperate with the client city (in some cases, the technical provider might even belong to the same parent public entity as the B2C MaaS operator, as in Vienna). Given that PTAs ideally have planning skills and operational power, have already acquired and retained a sizable customer base, and, most importantly, a mandate to provide transportation services for everyone at as fair a price as possible, these lead their MaaS schemes and handle the inclusion of and contracts for the many MSPs, whereas the B2G technical providers are in charge of everything platform-related (further explored in the following subsection). The influencing power thus remains on the public MaaS operator's side and the technical provider fully cooperates.

B2B MaaS operators usually opt for a wait-and-see approach, and shape their business according to the particular corporate mobility policies of the client companies' location(s) of operation. B2B MaaS operators generally have little affiliation with the public sector, and their influencing power upon other entities in the MaaS ecosystem can be considered as, for the most part, lower when compared to their B2C counterparts. However, should a B2B MaaS operator achieve a significant scale, and it would increase its influence and leverage within the ecosystem as well.

4.8 Partners

At the core of the MaaS ecosystem lie the many MSPs, namely the public transport operator(s), which constitute the MaaS provider's key partners, in addition to the technical providers, the payment service providers (PSPs), the end-customers, and further players (see section 2.4.1).

The relationship with said partners, however, greatly depends on the approach of the MaaS operator itself and its position as a private or public sector entity; Kamargianni and Matyas (2017) found from interviews conducted with MSPs that private mobility service providers such as car-sharing companies are more inclined to partner with privately owned MaaS operators, since they believe the latter have more incentives to facilitate the provision of their services. Indeed, in the case of Whim in Helsinki, MaaS Global granted private MSPs with freedom to adapt their service offer, while also seeking to attract multiple other MSPs in the process, as there is no particular relationship between the operator and any particular MSP. On a general level, however, and for a partnership to be feasible, the MSPs must possess the technical requirements for entry into the MaaS platform (further explored in section 4.11) and include appropriate mobility services/packages in their service offer.

As mentioned in the previous section, partnering with PTAs also emerges as a potential hurdle for privately led B2B and B2C MaaS initiatives. Should no regulation exist to impose the availability of all public transport tickets, and the PTA might resist in providing them to MaaS operators. In 2018, an executive of Dutch B2B MaaS company Tranzer highlighted this resistance as the largest obstacle to MaaS adoption as, at the time, not all transit tickets were available in the market (Zipper, 2020).

B2B operators, however, tend to partner with less conventional yet relevant actors in the MaaS ecosystem, as such partnerships might add value to a particular client company. These might include co-working space providers, parking companies, event managers, road operators and so on. Furthermore, it is customary for B2B MaaS schemes to include a payment card in their offer, thus allowing the clients to access further services from providers who might not be partnered with the MaaS operator (albeit in a less integrated manner, since the client not only is unable to pay with the MaaS application, but also will likely not be able to access functions such as route-planning for such services); for instance, an employee travels abroad and uses his mobility payment card to pay for public transport, taxi, or parking, and the total consumption is included in the monthly bill aggregated by the B2B MaaS operator.

On the public sector side, collaboration with the PTOs is most likely guaranteed, either because the MaaS operator role is filled by the PTA itself or by an overarching public/local authority. However, partnerships with further ecosystem actors are dependent on the particular objectives of the operator and possibly necessitate the approval of not only the PTO, but also other MSPs that already had a strong relationship with the public transport operator. In Hanover, for instance, car service companies weren't able to join integrate the local publicly-led MaaS scheme, due to opposition from the transport authority's partner taxi company (Cerema, 2019). In such cases, MaaS schemes whose integrator role is fulfilled by the PTA might be perceived as less sophisticated and consumer focused.

An alternative strategy might be the approach undertaken in Vienna, where the underlying MaaS platform for the publicly-led WienMobil MaaS scheme was developed by a publicly-owned B2G technical provider, yet allows other MaaS operators to plug into it and connect to the multiple integrated MSPs (for instance, MaaS Global uses this platform to operate its Whim app in Vienna), generating competition and the freedom for these to offer innovative services, while also steering their actions through the imposition of appropriate rules and guidelines. Having these MSPs integrate the open platform and partner with the MaaS operator is not guaranteed, however. Cerema (2019) point out how participating on such a platform is advantageous should the MSPs be relatively unknown, but as they gain prominence, some of them aspire to become platforms themselves and are therefore increasingly hesitant, as was the case in Vienna with REACH NOW and UberJump.

As expected, the B2C MaaS operator and the B2G technical provider will have different responsibilities within the established partnerships. The former will generally leverage its authority and expertise in the transport ecosystem through the management of the multiple partners (i.e MSPs) and by overseeing the contracts that need to be arranged for the provision of services. The latter will be responsible for integrating these MSPs in the platform and ensuring their interoperability, in addition to integrating the ticketing system of the PTO (section 4.11).

Regardless of the business approach, all partners should ideally be addressed by the principal operator as equals. Responsibilities are mutual, and so is the end-goal: to provide integrated multimodal mobility to the end consumer. Impartiality and integrity on behalf of all the ecosystem's actors is pivotal to achieve long-lasting, beneficial partnerships.

4.9 Exposure and marketing

This subsection refers to the means undertaken by B2B or B2C MaaS operators to reach the end-consumers. The MaaS scheme's website and application should clarify the type of transportation services included in the offer, as well as pricing, timetables, future products and packages, and so on (Polydoropoulou et al., 2020). Furthermore, channels such as social media and email, as well as search engine optimization should be utilized.

Other partners play a crucial role as well; the technical provider should promote the platform it developed, along with its features, in the form of white-papers, studies conducted by research

institutes, and so forth. The benefits are twofold, as it generates awareness for the particular MaaS scheme developed and advertises its technical expertise to other potential client cities as well. It must also be noted that the end-consumer might be accustomed to customer support from the individual MSPs, which is why it is paramount for the MaaS operator to develop an efficient, comprehensive array of customer support services for the provision of MaaS. The operator and technical provider must therefore coordinate the delegation of support-related responsibilities with the MSPs. In the same note, a risk regarding brand-image might emerge, as the MaaS operators might either strengthen or undermine the direct relationship the transport authorities have with commuters; these have spent numerous resources building up a brand, and a MaaS intermediary may weaken it (Zipper, 2018).

4.10 Regulatory framework

Arguably the single most recognizable challenge in MaaS development and adoption, the regulatory framework ultimately guides the actions of every constituent of the MaaS ecosystem. Should it work against a multi-modal, user-centric transport system, and MaaS will most likely not reach ubiquity.

The approach of private B2B and B2C MaaS operators with regard to the regulatory framework is, for the most part, one of compliance and attempting to persuade legislation in favor of MaaS, since these don't embody the role of transport regulators. In many countries, however, a paradigm shift in transport policies has been evident, mostly driven by European and national goals to increase sustainability by reducing congestion, pollution, CO2 emissions, accidents, and so forth. Countries that not only recognized the pertinence of such issues, but also acknowledged the possibility for MaaS to directly tackle them, have consequently taken MaaS-enabling measures namely at the data level. Examples of these include the United Kingdom, Finland, Belgium, among other countries that have imposed legislation making it mandatory for transport operators to open their data via APIs. In such a context, MaaS initiatives, B2B or B2C, private or public, have a higher chance of gathering initial traction, since they are able to, up to a certain extent, bypass certain hurdles such as the need to verify if the transport operators in their location of operation are willing to open their data. Nevertheless, some transport operators might have open data in incompatible formats, or without the desired quality, and as such, this risk should be considered in the MaaS operators' approach.

A lack of regulatory measures entails other kinds of risks, albeit for the public interest; for instance, if no regulation surrounding the fair inclusion of MSPs is imposed, then there might be a tendency for purely financially attractive partnerships. Although this is not a risk in itself, this financial attractiveness might come at the cost of the inclusion of less sustainable MSPs (an elementary example could be partnering with a moped-sharing company as opposed to the city's bike-sharing program) or providing MaaS in exclusively higher-income areas of the city where the likelihood for profit is greater. The argument also sways in the other direction; excessive regulation will likely prevent private MaaS operators and MSPs to adequately run their operations

and/or innovate, rendering any sort of approach or strategy for MaaS provision ineffective - for instance, in multiple countries, the regulatory structure for public transportation states that no entity other than the PTO may sell tickets (Li and Voege, 2017).

Public B2C MaaS operators' approach to the regulatory framework should entail a more active stance; because PTAs are usually transportation regulators as well, these will likely have the means to accelerate new regulation in the direction of MaaS. Furthermore, MaaS may serve as a decision-making tool for local governments as well as a mobility "command center" i.e a mechanism for administering the city's mobility strategy; route recommendations, for example, might be tailored to meet the demands of the city, such as avoiding temporary work zones, pedestrianizing particular districts, expanding the transportation options in specific regions, and so on (Capgemini Invent, 2020). In addition, since the public MaaS operator will also likely need to meet sustainability goals, its approach might prioritize the inclusion of sustainable MSPs such as (electric) single-occupancy vehicles, namely bicycles, e-mopeds and e-scooters.

B2G technical providers must also develop the platform according to the policy objectives of the client local/transport authority. Moreover, if the particular B2G technical provider is owned by the public sector, then the local authority behind the MaaS scheme can better conduct the actions of other MaaS operators utilizing the back-end platform. At a B2B level, the aforementioned case of Belgium serves as an example of a regulatory enabler, as the Law on the Mobility Budget helped paved the way for B2B MaaS operators to explore the corporate mobility niche albeit in a sustainable, tax protected manner (section 3.4.2.2).

4.11 Data/APIs

The last stage of the framework's Ecosystem perspective dives further into the pertinence of data within the context of MaaS. As stated in section 4.10, the non-availability of open data is indeed one of the primary issues that newly-imposed MaaS-enabling transport policies attempt to tackle, and as such will be explored in more detail.

In order to develop a comprehensive MaaS platform, the B2G technical providers or B2B/B2C MaaS providers (should the latter integrate the platform themselves, such as MaaS Global) will need to integrate the ticketing, booking, mapping and route calculation (among other) APIs from the various private/public MSPs, mapping service providers and PSPs. However, the complications arise beforehand; unless imposed by regulation, the service providers do not necessarily need to develop these APIs via which they would grant the MaaS operator or technical provider with access to their static and/or real-time data, which means that the operator and technical provider's approach should entail the possibility of verifying if these service providers are willing to develop said APIs in the first place. In addition, and assuming these APIs in fact already exist, the MaaS platforms confront interoperability challenges such as heterogeneous interfaces and data among the many MSPs; thus, standardizing these might be a necessity, as to enable the platform to interface with each MSP. This is precisely why MaaS Global, for instance, chooses to integrate MSPs

based on criteria such as the availability of high-quality open data and the openness of the ticketing mechanism.

The B2G technical provider's approach to building the platform should therefore aim to establish common rules and standardized interfaces/APIs in an effort to eliminate the aforementioned technical and organizational hurdles at an individual level (Sharp, 2017). Furthermore, since it collaborates with a city's local and/or transport authority on the development of the B2C MaaS scheme, access to public transport data proves to be a lesser issue since it is in the latter's interest to make it open (it will require time and resources to do so, however). Should no regulation exist to impose rules on open data to the remaining MSPs, and the local authority can also put effort in attempting to shift transport policies towards the direction of MaaS. Moreover, the technical provider should consider in its strategy the possibility to leverage the data it gathered and technology it developed by providing services to other players such as cities or businesses; Citymapper, Upstream Mobility and Trafi are all examples of companies undertaking such approaches, having provided data-enhancing services and licensing its proprietary software to other cities.

B2B MaaS operators should take a similar approach; it is customary for these to develop their platforms in-house, which enables them to process and evaluate the data retrieved on trips undertaken by their clients for the purpose of obtaining valuable insights, enhancing their in-house routing algorithms (resulting in improved trips) and better tailoring staff incentives. However, issues regarding individual data privacy rights and respective ownership might emerge, and as such these should be taken into consideration. Furthermore, technology providers should be mindful of the ever-increasing users' demand for data (in real time) and construct the platform so that it can bear the increase in data flow and storage-related requirements.

Taking into account the wider transport data-related regulatory framework is pivotal; as previously mentioned, the Finnish Transport Code aided the operations of MaaS Global through laws imposing public transport data to be open (despite having caused HSL to spend several hundred thousand euros in the development of their OpenMaaS API), facilitating the integration of public transport in its Whim MaaS scheme. London's transport authority had already opened its data, providing its APIs to a myriad of app developers, and had introduced EMV ticketing and payment systems for most forms of transportation, paving the way for Citymapper PASS's multi-modal card-based mobility service as well as providing crucial information to MaaS operators and other mobility companies on when and where people utilize public transport. In many metropolitan areas, such favorable regulatory environments are simply not the case, and challenges regarding data availability/sharing between the many MSPs are more apparent. Ideally - for MaaS operators, technical providers, MSPs and consumers alike - a common language would be defined by regulation, composed of data standards and APIs on an international level (Capgemini Invent, 2020), where institutional issues of MaaS such as trust between the involved actors in the ecosystem (Polydoropoulou et al., 2020) could be mitigated by the existence of a level, organized playing field.

Chapter 5

Case study - Lisbon, *Portugal*

The principal purpose of this chapter is to exemplify how the proposed framework could be applied in a particular metropolitan context. Accordingly, section 5.1 will first explore Lisbon's transportation and mobility environment, presenting an overview of available public and private transport modes, integrated payment systems and citywide MaaS-oriented initiatives; section 5.2 builds on such an overview while analyzing additional key insights and presents the applied framework, categorizing the main takeaways according to the respective criteria and overarching business approaches.

5.1 Mobility in Lisbon

As Portugal's capital and largest city, Lisbon is home to around 500,000 people within an area of 100 km^2, while its metropolitan area covers 18 municipalities, equating to a population of 2.8M within 3,000 km^2, of which 1.3M are active.

In 2008, mobility became one of Lisbon's core policies and as such, efforts were made to electrify transportation and to increase the city's sustainability. Lisbon's municipal transportation company Carris, for example, aims to strengthen and electrify the public transport system by increasing the fleet with 420 electric buses and 25 trams by 2023. The plan will cost 252 million euros and ultimately aims to convert 150,000 individuals who drive private automobiles to utilizing public transportation by 2030 (Herranz, 2020; Wray, 2019).

Furthermore, the emergence of new mobility service providers, particularly since 2015, helped evolve Lisbon's transportation network, complementing the city's public transport system with, for instance, 12,000 shared e-motorbikes from 9 different companies (Herranz, 2020), as well as bikes, scooters and shared cars. On the other hand, Lisbon's more traditional inner urban mobility is provided by a metro and light rail systems, with the commuter transport being supplied by various commuter trains and ferries which articulate with numerous public and private bus operators; furthermore, each operator has made efforts to improve and integrate ticketing, which is why Lisbon has an inter-modal transport ticketing system utilized by all the principal public transport operators (Cruz and Sarmento, 2020). However, this system - known as VIVA and operated by OTLIS -

does not integrate other recent mobility service providers nor does it fully digitize the travel experience, as a physical travel card is still necessary (thus, solely tickets are integrated); conversely, the publicly-owned authority that oversees Lisbon's street parking (EMEL) has developed its own mobile application for parking in any given area of Lisbon, in addition to providing bike-sharing technology (ePark) (Cruz and Sarmento, 2020). Via Verde (majority owned by private transport infrastructure operator Brisa) also leveraged its expertise as Portugal's reference digital payment system for paying highway tolls to develop a service for smart public transport ticketing, parking and car-sharing (Cruz and Sarmento, 2020).

Strategies regarding the way mobility data is handled prove to be crucial, should a city be aiming for a MaaS-friendly regulatory framework. As such, Lisbon has embraced the Mobility Data Specification (MDS), creating a framework for dockless bikes, e-scooters, and other shared MSPs to share data in order to inform and aid public transportation planning and administration (Ribeiro, 2020). Moreover, and in an attempt to improve the quality of mobility information within the most prominent third-party journey planners (Waze, Citymapper, Google Maps, Apple Maps, etc.) and potential MaaS implementations operating in Lisbon, the City of Lisbon is developing a database of crucial mobility infrastructure data (referred to as the mobility catalogue) which can be pushed out via APIs to app providers, granting these with a source of reliable, up-to-date information that goes beyond the data usually supplied through General Transit Feed Specification (GTFS) thus including more intricate information like real-time events, as well as infrastructure information on underpasses, bus lanes, and so on (Wray, 2019).

As previously mentioned, multiple transport options make up Lisbon's mobility space, each reaching the city's urbanites through multiple mobile applications (see section 5.2). However, and even though this offer is generally expanding, the effects of the COVID-19 pandemic saw nonetheless a decrease in certain services in 2020/2021 - an example is DRIVE NOW, which, after ceasing operations in Lisbon in March of 2020, was expected to relaunch its service as SHARE NOW shortly after, but is yet to do so (Pinto, 2021). Nonetheless, such a fragmented yet abundant landscape of last-mile solutions paves the way for a system capable of aiding the last-mile issues inherent to public transport, and creates the opportunities for a new MaaS scheme to attempt the integration of these public and private offerings - since Lisbon still lacks the crucial element of bringing all these modes of transport together in one seamless interface (Witzel, 2018) - while leveraging on the data-related strategies undertaken by the city of Lisbon; indeed, according to Cruz and Sarmento (2020) mobility applications and MaaS strategies in Lisbon will undoubtedly blend into truly integrated services, in the medium to long run.

Cascais, a neighboring city constituting one of the 18 municipalities in the Lisbon metropolitan area, has, in fact, fostered a mobility scheme of its own. In an effort to not only accommodate the fluctuating population, but also secure a position as a world-class tourism destination, the city of Cascais launched MobiCascais in 2016; with this platform, a user could book, manage, and pay for bike and car-sharing services, smart parking, taxis, transport on demand, carpooling, electric vehicle charging, and could access information on public transportation routes and stations, all through an app and a web portal (Sluismans et al., 2019), accounting for 2,000 shared

bicycles, 300 parking kiosks, 1,280 parking spaces, 12 bus lines, and an electric-vehicle-charging network by mid-2017 (Antunes, 2018). At the back-end level, an integrated platform managed real-time information regarding all multi-modal transportation systems, and therefore allowed for the management of urban logistics and traffic. It is based on the mobi.me system, a smart urban mobility management solution devised by the Portuguese Center for Excellence and Innovation in the Automobile Industry (CEiiA) and already in use in a number of cities across the world (Antunes, 2018). As of 2021, however, some services are no longer available, such as car-sharing, or even bike-sharing which was suspended due to the COVID-19 pandemic. Efforts towards an easily accessible and sustainable mobility system are nonetheless being undertaken; for instance, in February of 2020, public road transport became free for all residents, workers and students registered in the MobiCascais platform.

5.2 Application of the proposed framework

The application of the framework entailed a deeper understanding of Lisbon's mobility context; as such, an overview of Lisbon's legacy and new transport services, as well as payment apps and systems (as of 2020) is presented in Figure 5.1.

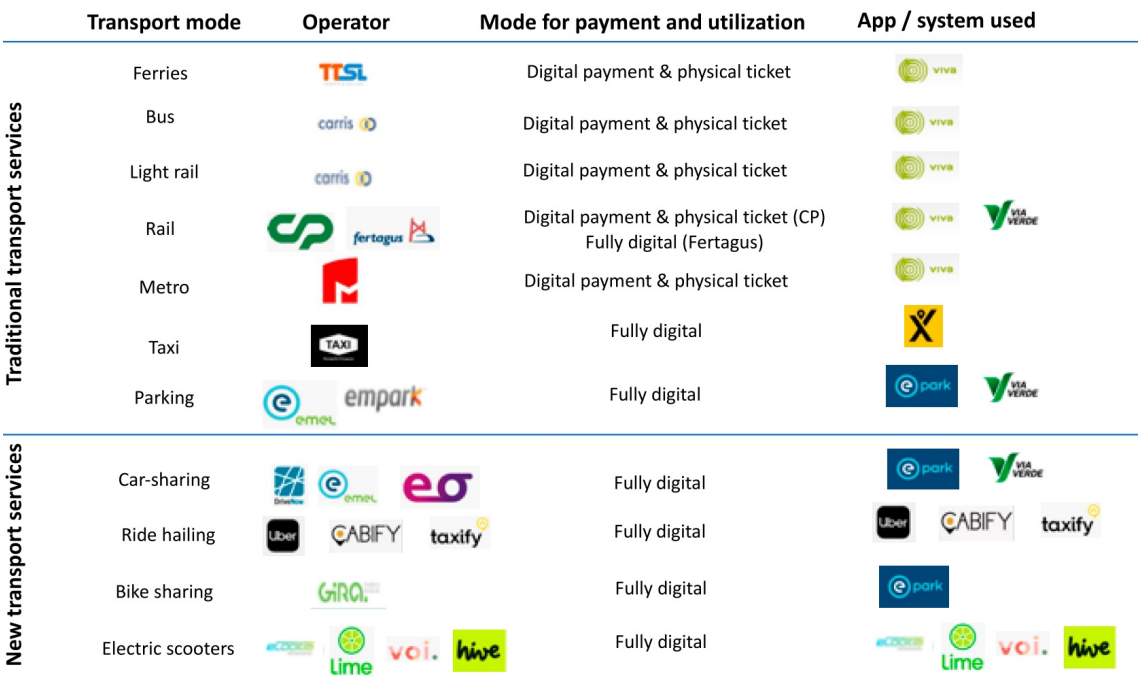

Figure 5.1: Transport operators in Lisbon, reproduced from Cruz and Sarmento (2020)

The main legacy PTOs are represented by Carris (operates Lisbon's buses, trams, and funiculars), Comboios de Portugal (CP - operates passenger trains), Fertagus (operates commuter rail) and Metropolitano de Lisboa (ML - operates Lisbon's metro system). Furthermore, and as mentioned in the previous section, certain new MSPs displayed in the figure (namely DRIVE NOW) have since ceased operations in Lisbon.

Statistics regarding public transportation usage were sourced from INE (2018); although not entirely up-to-date, these data still allow for an adequate overview of the population's attitude towards public transportation, especially given it represents a pre-COVID-19 context that is more representative of Lisbon's regular public transportation usage.

The framework was developed with insights from key people at Deloitte, assessing not only certain assertions and statements made in the framework, but also providing information namely at the level of Lisbon's municipality approach to mobility data and new MSPs. Furthermore, and given there are effectively 18 municipal transport authorities that comprise the Lisbon Metropolitan Area, the use of acronyms such as PTO and PTA is preferred as to not highlight a particular entity or transport operator. This is because, in the context of the framework's hypothetical scenarios, the role of, for example, the Public MaaS operator can be played by any adequate entity, albeit usually a PTO or a PTA. A similar logic applies to the MSPs, given that, for the purpose of the application of the framework, highlighting a particular MSP is usually not necessary; nevertheless, and when deemed appropriate, concrete examples of entities are included in the framework.

	Business-to-Business	Business-to-Consumer	Business-to-Government
Size of potential userbase	- Active population of 1.3M (metro) - Motorized individual transport is usually preferred - Bulk of Portugal's major (multinational) corporations located in Lisbon	- Targets residents, visitors and tourists - Population of 2.8M (metro), with 15,8% of people using public transport as main means of travel	
Cost structure	- Investment costs (in-house or outsourced design & development of platform + app) - Operational costs (fixed: amortization, marketing, maintenance of platforms, legal, data security/privacy; variable: service provision, customer support, personnel, insurance) - Possible cost efficiency should the MaaS operator be a public or private company with previously developed mobility platforms (e.g Brisa)		- Costs incurred by providing MaaS solution to client (development and maintenance of app + platform, data privacy/security costs) - Possible cost efficiency gains (ready-to-use white label app + platform)
	- Covering initial costs might be faster (userbase composed of paying customers + bigger margins)	- Covering initial costs requires time and scale	
Revenue stream(s)	- Mark-up on particular mobility solutions/budget provided to client companies - Private funding	- Commissions charged to MSPs on pay-as-you-go model (however, slim margins require considerable scale) - Mark-up on subscription model - Other streams (e.g advertising) - Private funding (in the case of private MaaS operator) or public funding (public operator)	- Provision of necessary technical solutions (platform + app) and expertise to MaaS operator(s) - Private funding (in the case of private technical provider) or public funding (public technical provider)
Service adherence	- Public transport service-level might not be adequate for needs of MaaS users (45,3% of residents only use public transport because they either have no car or do not drive)		
	- Commuting represents one of the biggest use cases for MaaS - Large proportion of people with company cars suggests a possible market, but might prove difficult to cause a switch in mobility practices	- Pay-as-you-go better targets prominent tourism sector - 35,7% of Lisbon's metropolitan population uses public transport for cost-related reasons: risk in non-adherence to subscription model - Presence of many other mobility applications challenges adherence	- Authorities might need convincing - A proven track record in other cities aids in achieving a partnership
Adaptation to clientbase	- Solution must be company-tailored (company location, commuting habits of employees, client mobility requirements, specific billing solution)	- Pay-as-you-go entails a one-size-fits-all strategy - Subscription model might need to be flexible (weekly subscriptions in addition to monthly) to target temporary visitors and tourists as well	- White-label app + platform must nonetheless be fit for the client PTA/PTO
Culture and consumer behavior	- Prominent car culture - Motorized individual transport is preferred by 59,8% of people -Both the economic and non-economic benefits of MaaS (i.e convenience and reduced journey times) need to be clear and substantial enough to lower reliance on cars		
	- MaaS must be recognized as a valid corporate transport/benefit	- Abundance of micromobility operators in Lisbon might tackle the first/last-mile problem to an extent	

Figure 5.2: Framework applied in the context of Lisbon

	Business-to-Business	**Business-to-Consumer**	**Business-to-Government**
Influence	- Medium (assuming large corporations i.e EDP, Galp or JM adhere to B2B MaaS, these would influence the B2B MaaS status quo in Lisbon)	- High (local authority/PTA/PTO initiative) - Medium (if private)	- Medium (PTO/PTA leads MaaS initiative, but technical provider is in charge of platform + integrations)
Partners	- Private MaaS operator might be more attractive to Private MSPs (whether these are micromobility or road toll operators like Brisa-Via Verde) - Private MaaS operator might face challenges regarding integration of PTOs (e.g ticket availability)		
	- Possibility to partner with more business-focused services (e.g partnering with CP or Fertagus to include intercity train trips for business commuters)	- Collaboration with PTOs is better ensured (in the case of a public MaaS scheme) - Assessing the value each potential ecosystem player can bring is key, as to achieve a possible yet worthy compromise, i.e assessing which entity can provide which service, avoid clash of interests (presence of multiple public and private PSPs such as OTLIS and Via Verde might generate friction)	
		- Some resistance might occur from PTOs not wanting certain MSPs included in the Public MaaS scheme	- Choosing which entity (city authority/PTA/PTO) to directly partner with is crucial (e.g ML, EMEL, Carris, Lisbon city hall) - Regardless of chosen entity, ensuring all of them are on-board is crucial
Exposure and marketing	- A deep-focus on the appropriate orchestration of customer support efforts is essential		
	Focus on B2B marketing (e.g targeting potential companies through LinkedIn ads) in addition to website, other social media, email, search engine optimization	- Intuitive website and app, clear service offer, pricing, timetables, future products and packages, as well as social media and search engine optimization	- Promotion of developed platform through white-papers, research institutes' studies, etc.
Regulatory framework	- Lisbon municipality's approach to (new) MSPs is a key enabler (i.e allowing them to enter the market before regulating their operation - 'enable first, regulate later')		
	- MaaS must be recognized as a valid corporate transport/benefit (e.g incentivize mobility budgets as opposed to traditional company cars)	- Risk of first/last-mile solutions not covering outer areas of Lisbon if no adequate regulation is put in effect	
Data/APIs	- Lisbon municipality's approach to (new) MSPs proves as a key enabler for MaaS (i.e incentivizing said MSPs to open their data, Mobility Catalogue initiative) - Common ticketing (VIVA, operated by OTLIS) for public transport exists but must be digitized (otherwise, an alternative would be a card-based MaaS like Citymapper PASS) - The developed MaaS back-end platform must standardize data and interfaces		
		- Mobility Data Specification in Lisbon helps the public MaaS operator and PTOs	

Figure 5.3: Framework applied in the context of Lisbon (continued)

Chapter 6

Conclusion and discussion

The transportation sector is undergoing an eminent paradigm shift; indeed, ever-altering mobility patterns and advancements in information technology have enabled the emergence of a myriad platforms with which urbanites are able to access a comprehensive range of on-demand mobility services. Furthermore, aggravated congestion of established road networks and systems throughout the world has called for the undivided attention on behalf of urban transportation planners and authorities alike. Accordingly, Mobility as a Service arises as a connected, multi-modal and user-centric transport model that aims to tackle such issues by proposing a change from ownership to comprehensive mobility access.

The present document aimed at providing a comprehensive understanding of MaaS through grounded research on its integral characteristics and features as well as its business context. Moreover, it intended to explore the current strategies and implementations of MaaS being undertaken at a European level, through a comprehensive benchmark of heterogeneous schemes and players. This culminated into the last purpose of this document, corresponding to the development of a comprehensive framework for the analysis of three distinct MaaS implementation approaches. The framework was built upon the conjugation of the prior benchmark and literature review, and proposed 11 criteria against which the B2B, B2C and B2G approaches were analyzed and compared. In order to not only exemplify a use-case for the proposed framework, but also append additional value to the project fostered by Deloitte Portugal, a case study of MaaS in Lisbon was presented, within which the aforementioned strategies were analyzed through the application of the developed framework.

The contributions of this paper commence with the comprehensive aggregation of key MaaS insights at both the theoretical and practical level. The European overview, for instance, provides the reader with the state-of-the-art of schemes and efforts of MaaS, yet does so with regard to the enablers and barriers of each respective area of operation, as to present the overall context that supported such developments. Furthermore, this is done at both the feature and business-levels, thus compiling two distinct areas of MaaS research.

Developing the framework entailed a similar approach: the criteria identified, indeed, stemmed from a more conceptual point-of-view, with part of their underpinnings originating from the litera-

ture review, but were nonetheless addressed with tangible takeaways from the feature and business-level benchmarks alike. Likewise, the framework was also applied to a practical urban context, allowing for the demonstration of a more detailed and city-specific use-case.

Utilizing the proposed framework to analyze MaaS implementation approaches in the city of Lisbon addresses the inherent limitations of, for instance, resorting to established frameworks for strategic analysis such as SWOT or PESTEL, which, despite representing tried-and-tested tools for assessing the internal competencies and external factors that dictate the feasibility of an entity's strategic endeavors, are not tailored for a specific sector or particular scenarios, given their multipurpose and versatile nature.

Nevertheless, the present study on Mobility as a Service is not without its shortcomings. In particular, it has not fully explored pertinent matters such as 1) the role of automotive Original Equipment Manufacturers (OEMs) in the MaaS sector, 2) the potential of autonomous vehicles to disrupt the transportation and shared-mobility market and 3) the implications of MaaS on data privacy and security, which, although briefly touched upon in the previous chapters, were not accentuated enough; indeed, addressing the implications of potential abuse of end-users' data on behalf of the data-handlers is paramount, as its misuse might lead to severe repercussions.

Further research could also be conducted as to expand the scope of the project to a regional level, where the approaches of MaaS schemes such as wegfinder and yumuv could have been benchmarked and later analyzed with the proposed framework. Additionally, the scope of the framework focuses on the implementation stage of MaaS, and could be broadened as to address later stages such as the long-term maturity of the service by incorporating appropriate criteria. Moreover, the developed framework does not present concrete comparison metrics which would have otherwise provided the foundation for a quantitative juxtaposition of the identified MaaS approaches, nor does it establish a defined order of criteria importance which would aid the practitioner in assessing said approaches by prioritizing certain criteria over others. On a similar note, the cause-and-effect relationships between the criteria, although suggested with the proposed numerical order, were not concretely outlined and would have otherwise complemented the framework's structure. With regard to the Lisbon case study, interviews could be conducted with stakeholders in order to complement the research approach; nevertheless, the project was developed under the supervision of Deloitte Portugal, providing the necessary contact points as well as crucial insights for the case study.

The concept of Mobility as a Service entails a change at multiple levels; the implementation of MaaS platforms must undoubtedly be accompanied with the necessary physical infrastructure adaptations and regulatory efforts that together will enable a shift to a user-centric multi-modal transport paradigm. Nevertheless, studying the European MaaS landscape and present-day approaches to such implementations is paramount as it aids in understanding upcoming challenges that will be faced by practitioners.

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