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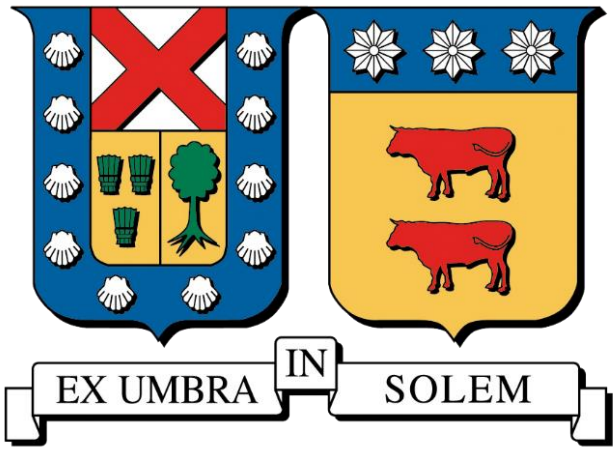

SHARED MOBILITY AND MULTIMODAL TRANSPORTATION

CHALLENGES ON THE INTEGRATION OF SHARED MOBILITY AS A MULTIMODAL OPTION FOR URBAN MOBILITY UNDER THE MAAS PARADIGM

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OCTUBRE 2018

TRABAJO DE TÍTULO REALIZADO DENTRO DEL PROGRAMA DE DOBLE TITULACIÓN EN CONJUNTO CON EL

POLITECNICO DI MILANO
ESCUELA DE INGENIERÍA INDUSTRIAL Y DE LA INFORMACIÓN
MILÁN, ITALIA

OBTENIENDO EL GRADO DE
M.SC. IN MANAGEMENT ENGINEERING

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“Shared mobility is not a question of morale, but of designing an intelligent infrastructure for the needs of the users and the environment.”

Gabrielle Gerhardter

Abstract

According to the European Commission (2017) urban mobility is responsible for about 40% of all CO_2 emissions of road transport, and up to 70% of other pollutants. At the same time, congestion costs around 1% of the EU's GDP annually. These problems make imperative the pursuit of new alternatives to promote a more sustainable urban mobility system.

In the last years, together with the new socioeconomic phenomenon of the Sharing Economy, a new concept of mobility has arisen encouraging access rather than ownership of vehicles: the Shared Mobility, with different modes as car-sharing, bike-sharing and ride-sharing. Even more recently, a new paradigm for mobility referred to as Mobility as a Service (MaaS) has appeared, offering customers mobility services as packages based on their own needs, integrating various transportation services into a single platform.

This work aims to explore how Shared Mobility is currently being integrated as a multimodal option for urban mobility under the MaaS paradigm in different European cities, in order to identify its role as a multimodal option and possible challenges and barriers that could be faced during the integration. For this, 4 cases of implementation in the cities of Leipzig, Gothenburg, Vienna, and Toulouse are presented. The first one is about integration through Mobility Stations (Leipzig Mobil). The second and third one are about successful MaaS pilot programs (UbiGo and SMILE), contemplating also a current full operative MaaS platform in the third case (WienMobil). Finally, the fourth case presents a program to promote carpooling as a multimodal option for business centers in the city (CHUMS project).

The conclusion of this work is that shared modes can play a role as a multimodal option for urban mobility, as a support for the first/last mile around public transport (the backbone of urban mobility). This integration can take place either in physical or/and digital ways. Key challenges for integration were identified, as funding, physical space availability, public transport development, partnerships and collaboration, cultural paradigms, and others.

Abstract (Español)

De acuerdo a la Comisión Europea (2017) la movilidad urbana es responsable de alrededor del 40% de las emisiones totales de CO_2 del transporte por calles y carreteras, y de hasta el 70% de otros contaminantes. Al mismo tiempo, la congestión es identificada como responsable de un costo anual de alrededor del 1% del PIB europeo. Estos problemas hacen necesaria la búsqueda de nuevas alternativas que promuevan un sistema de movilidad más sostenible.

En los últimos años, junto con el fenómeno socioeconómico de la Sharing Economy (o Economía Colaborativa), nace un nuevo concepto de movilidad que promueve el acceso por sobre la propiedad de vehículos: la Shared Mobility (o Movilidad Colaborativa). Aparece también un nuevo paradigma para la movilidad llamado Mobility as a Service (o Movilidad como Servicio) MaaS, mediante el cual se ofrecen servicios de movilidad como paquetes, integrando diferentes servicios de transporte en una única plataforma.

Este trabajo busca explorar cómo la Shared Mobility está siendo integrada actualmente como opción multimodal para la movilidad urbana dentro del paradigma MaaS en diferentes ciudades europeas, con el fin de identificar su rol como opción multimodal y los posibles obstáculos a los que se podría enfrentar durante la integración. Se presentan 4 casos de implementación en las ciudades de Leipzig, Gotemburgo, Viena y Toulouse. El primero trata del proyecto de integración con Mobility Stations (Leipzig Mobil). El segundo y tercer caso tratan sobre programas piloto de integración a través de sistemas MaaS (UbiGo y SMILE), incluyendo una plataforma completamente operativa en el tercer caso (WienMobil). El cuarto caso presenta un programa de carpooling implementado en zonas comerciales de la ciudad (CHUMS).

Este trabajo concluye que las modalidades colaborativas pueden jugar un rol como opción multimodal para la movilidad urbana, como un apoyo para la primera y última milla alrededor de la red de transporte público (la columna vertebral de la movilidad urbana). Esta integración puede ser tanto física como digital. Algunos de los principales desafíos a enfrentar son el financiamiento, la disponibilidad de espacios, el desarrollo del sistema de transporte público, las alianzas de colaboración, y los paradigmas culturales, entre otros.

Abstract (Italiano)

Secondo la Commissione Europea (2017) la mobilità urbana è responsabile di circa il 40% di tutte le emissioni di CO_2 del trasporto stradale, e fino al 70% di altri inquinanti. Allo stesso tempo, la congestione costa annualmente circa l'1% del PIL dell'UE. Questi problemi rendono imperativo il perseguimento di nuove alternative per promuovere un sistema di mobilità più sostenibile.

Negli ultimi anni, insieme al nuovo fenomeno socioeconomico della Sharing Economy (economia di condivisione), è sorto un nuovo concetto di mobilità che incoraggia l'accesso piuttosto che la proprietà dei veicoli: la cosidetta Sharing Mobility (mobilità condivisa). Ancora più recentemente, è apparso un nuovo paradigma per la mobilità denominato Mobility as a Service (mobilità come servizio) MaaS, che offre ai clienti servizi di mobilità come pacchetti, integrando vari servizi di trasporto in un'unica piattaforma.

Questo lavoro intende esplorare come la Shared Mobility è attualmente integrata come opzione multimodale per la mobilità urbana nell'ambito del paradigma MaaS in diverse città europee, al fine di identificare il suo ruolo come opzione multimodale e le possibili sfide e ostacoli che potrebbero essere affrontati durante l'integrazione. Vengono presentati 4 casi di implementazione nelle città di Lipsia, Göteborg, Vienna e Tolosa. Il primo riguarda l'integrazione attraverso le Mobility Stations (Leipzig Mobil). Il secondo e terzo caso riguardano programmi pilota di MaaS (UbiGo e SMILE), e anche una piattaforma MaaS operativa completa nel terzo caso (WienMobil). Il quarto caso presenta un programma per promuovere il carpooling come opzione multimodale per alcune zone commerciali della città (CHUMS).

La conclusione di questo lavoro è che le modalità condivise possono svolgere un ruolo come opzione multimodale per la mobilità urbana, come supporto per il primo/ultimo miglio intorno al trasporto pubblico (la spina dorsale della mobilità urbana). Questa integrazione può avvenire sia in modo fisico o digitale. Sono state identificate le principali sfide per la sua integrazione, quali il finanziamento, disponibilità dello spazio, sviluppo del trasporto pubblico, partnership e collaborazione, paradigmi culturali, e altri.

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Executive Summary

Introduction, Objectives and Methodology

According to the European Commission (2017) urban mobility is responsible for about 40% of all CO_2 emissions of road transport, and up to 70% of other pollutants. At the same time, congestion is recognized as a common problem both in and around urban areas, and it costs around 1% of the EU's GDP annually. These problems, considering the constant growth of some European cities, make imperative the pursuit of new alternatives to promote a more sustainable urban mobility system. In the last years, together with the new socioeconomic phenomenon of the Sharing Economy, a new concept of mobility has arisen encouraging access rather than ownership of vehicles: the so called Shared Mobility. Even more recently, a new paradigm for mobility referred to as Mobility as a Service (MaaS) has appeared, enabled by the development of IT, offering customers mobility services as packages based on their own needs, integrating various transportation services into a single mobility platform accessible on demand.

This work makes an exploratory research of these concepts (Shared Mobility and MaaS), with the objective of analyzing the potential role of Shared Mobility within the MaaS paradigm as a multimodal option for urban mobility, at the same time as identifying possible challenges and barriers that could be faced in the attempt of integrating shared modes as a multimodal option. For this, besides the literature review of the concepts involved, 4 cases of implementation of shared modes as a multimodal option in European cities (Leipzig, Gothenburg, Vienna and Toulouse) are presented to show evidence of the current practices and get an insight of the relationships, processes and conditions needed for this kind of integration.

Shared Mobility and MaaS

Shared Mobility is the "division" of mobility of the Sharing Economy, one of the most significant global socio-economic developments over the last past decade that promotes access to shared products rather than ownership. Shared Mobility is defined as the shared use of a vehicle, bicycle, or other mode which enables users to gain short-term access to transportation modes on an "as-needed" basis. Shared Mobility services includes various modalities which differ one another depending on the vehicle involved, or even by the element that is being shared – the vehicle itself or a spot inside a vehicle. It includes various forms of car-sharing, bike-sharing, scooter-sharing, ride-sharing, and on-demand ride services.

This kind of mobility has been proven to have numerous environmental, social and transportation-related benefits to the cities where implemented. The impacts of Shared Mobility includes reduction of vehicle usage, reduction of ownership rates, reduction of vehicle kilometers traveled (VKT), reduction of greenhouse gasses (GHG) emissions, and transportation costs savings.

The main stakeholders involved in the context of Shared Mobility are users, shared mobility operators, transportation scientists, and public entities, being the latest of fundamental importance due to their role of regulators in topics regarding health and safety, taxation, insurance, parking and access to rights-of-way, signage and advertising, multimodal integration, planning processes, data sharing and privacy, and accessibility and equity issues.

More recently risen, another mobility concept has been introduced in the field of urban mobility attempting to approach the consumers' mobility problem as a need that has to be satisfied as a whole. This concept is known as Mobility as a Service (MaaS) and it consists on the integration of different transportation modes (among which it is possible to include shared modes) into a single mobility service, to make it easier for users to do multimodal connections and so make urban mobility easier. More specifically, MaaS services offer a digital platform (accessible through mobile apps) which works as a multimodal journey planner, providing recommendations of combinations of different transportation modes (including public transport, car-sharing,

bike-sharing, taxi, and others), a booking system, easy-payment, and real time information. MaaS is based on 3 key concepts that help providing seamless intermodal trips: payment integration (access to all the modes are billed to a single account), mobility package (customers pre-pay for a specific amount of a combination of mobility services), and ICT integration (a single app can be used to access real time information about all the modes).

In order to sustain these characteristics of operation of MaaS systems, cities have to meet some conditions in order to be suitable for the implementation of MaaS. This conditions include having a wide range of transport modes available, and majority of transport operators must be willing to open their data to a third party, let that third party sell their service, and offer e-payment to acces their service. MaaS system can be initiated by local authorities to make urban mobility in the city more sustainable, but it also may be operated in a city without official support of local authorities when the basic conditions have been met.

Cases of Implementation

Case 1 shows how City of Leipzig, in Germany, implemented a system of Mobility Stations: A set of stations which integrate public transportation stops with other modes as car-sharing, bike-sharing, taxi, and other mobility features as electric car charging stations and bike parking, complemented with a mobile app (Leipzig Mobil) as MaaS platform for information, booking and payment of the mobility service. Besides City of Leipzing, the project involved the participation of other organizations as Leipziger Verkehrsbetriebe (public transport operator), TAF mobile (platform operator), teilAuto (car-sharing provider), and nextbike (bike-sharing provider).

Case 2 presents a pilot program developed in Gothenburg (Sweden) by UbiGo: a mobile MaaS app which offered to the participants of the pilot the possibility to pay a subscription in order to have a certain amount of credits to use in mobility services as public transportation, car renting, bike-sharing, car-sharing and taxi. It started as a private-public partnership headed by the Lindholmen Science Park in a project that included many members as City of

Gothenburg and Västtrafik (public transport operator). The pilot program showed so good results (majority of the participants stated they wanted to stay as customers and that the solution was priceworthy) it received and OECD award for Promising Innovation. There is a full operative relaunch scheduled for 2018 in Stockholm, also as a consequence of the good results of the pilot.

Case 3 presents a pilot program launched in Vienna (Austria) of a mobile app very similar to the previous case. This app was called SMILE, and it was born from the initiative of the Ministry of Transport in partnership with other public and private entities (as Wiener Linien, the public transport operator). The app allowed users to have access to a variety of mobility services such as car-sharing, bike-sharing, public transport, taxi and parking through an easy-to-navigate mobile interface. This app would also keep users informed about the transportation modes available around their location, and help them select the most efficient route to their destination, providing them at the same time with pricing information, and allowing users to book tickets and rides directly through the app. Majority of the participants stated they were very content with SMILE. Good results allowed the creation of a new fully operative MaaS platform, but this time directly controlled by Wiener Linien, already operative since June 2017.

Finally, Case 4 presents a project called CHUMS in Toulouse (France) which integrated as a multimodal alternative for urban mobility a shared mode not included in the previous cases: ride-sharing (carpooling). This project was launched by SMTC-Tisséo (public transport authority), and it promoted carpooling between two business areas (TOP and Héliopole) and public transport points through a 3 steps program, which included a Carpooling Week to increase awareness, provision of Personalized Travel Plans (PTP), and the setup of a Mobility Jackpot competition. Results of this program showed an increase of between 10% and 20% of carpoolers.

Discussion and Conclusions

The conclusion of this work is that shared modes can play a role as a multimodal option for urban mobility, as a support for the first/last mile around public transport (the backbone of urban mobility), offering a more sustainable transportation service which could replace private ownership of cars and this way help to the reduction of pollution and congestion. This integration of Sharing Mobility as a multimodal option can take place either in physical or/and digital ways, through the use of mobility stations or/and a MaaS system, respectively.

Key challenges for integration were identified, among which is it possible to find issues like funding, physical space availability (in cases of physical integration), public transport suitability for multimodal connections, partnerships and collaboration between different actors, shift of cultural paradigms (from ownership to access), the integration of other shared modes (as ride-sourcing and ride-sharing) into MaaS systems, and other levels of integration considering other high traffic points of cities as supermarkets, universities, business centers, etc.

Chapter 1: Introduction

The context of urban mobility

Urban mobility is becoming an issue of importance in urban planning. The majority of European citizens live in an urban environment, and for their mobility they share the same infrastructure. Urban mobility is responsible for 40% of all CO_2 emissions of road transport, and up to 70% of other pollutants of transport (European Commission, 2017). At the same time, congestion in the EU is a common problem both in and around urban areas, and it costs around EUR 100 billion – 1% of the EU's GDP – annually (European Commission, 2017).

Ideally, to decrease pollution and congestion and make mobility more efficient, people should use shared-use transportation modes – as public transit – in order to make a better use of the available capacity in this kind of transportation modes and reduce the number of vehicles on the streets. Unfortunately, public transit cannot completely fulfill the mobility needs of every citizen, it cannot make stops in every single origin/destination point. Public transit operates as a fixed-route system, stops are set at specific locations to maximize efficiency. This leads to another problem: the First/Last Mile Problem (FLMP).

The First/Last Mile Problem

The concept of First/Last Mile (FLM) was originally conceived in the telecommunications industry, and it was referred to the final – or first – leg to the consumer in the connection between high capacity hubs to individual

units, which implied big but necessary costs. Later on, the concept of FLM began being used in the supply chain management world: it was used by logistic companies to describe their end point deliveries from centralized warehouses (Levinson, 2016).

In mobility, the term FLM has been used in recent years to describe passenger travel in the context of getting to/from public transit stops, considering public transit as the backbone of the mobility ecosystem. The First/Last Mile Problem (FLMP) arises when the walking distance from an origin/destination point towards a public transit stop is longer than a "comfortable distance", defined by each potential user and influenced by external and uncontrollable factors as weather and time of the day. This problem makes users decide between different options, including using a motorized private vehicle to reach the transit stop or even using a motorized private vehicle to do the whole trip, which results in more traffic congestion and pollution.

The new paradigms in mobility

The last decade has been the scenario of a significant global socio-economic development: the Sharing Economy, a new paradigm which prioritizes access rather than ownership of goods. Following this phenomenon, the paradigm of mobility has also started shifting from the private ownership of transportation modes for personal use, towards different mobility solutions that are consumed as a service.

The "division" of mobility of the Sharing Economy is referred to as Shared Mobility, which is defined as the shared use of a vehicle, bicycle, or other mode which enables users to gain short-term access to transportation modes on an "as-needed" basis (Shaheen et al. 2015). This new kind of mobility services offer users access rather than ownership, making transportation more accessible to people. Vehicles are accessed on a demand responsive modality, avoiding the high asset idle times related to private ownership, and reducing vehicle usage, ownership and vehicle kilometers traveled (VKT). Shared Mobility includes different modalities, as car-sharing, bike-sharing, ride-sharing, and on-demand ride services.

The inclusion of Shared Mobility as a mobility option includes the participation of different stakeholders: users (which shift from the ownership paradigm to favor accessibility), shared mobility operators, public entities and regulators (with fundamental roles related to health and safety, taxation, insurance, etc.), and transportation scientists.

Following the rise of Shared Mobility as a new kind of mobility mode, and enabled thanks to the development of IT, the paradigm shift has also brought a new transport concept for urban areas, which offers the integration of various transportation services into a single mobility platform accessible on demand. This new mobility service is known as Mobility as a Service (MaaS) and offer customers mobility services as packages based on consumers' needs, so consumers can buy mobility services provided by the same or different operators by using a single platform with a single payment channel. These mobility packages enable multimodal individual trips with different transportation options, among which it is possible to find public transport, taxis, car rentals, and Shared Mobility modes.

Relevance of the issue

Congestion and pollution are critical problems in today's societies, and being urban mobility a big responsible of that, it becomes imperative to find new alternatives to create more sustainable cities, taking in consideration both user needs and the environment. Shared Mobility is a potential alternative solution to solve this problem, reducing private vehicle ownership and hence the number of vehicles on the streets and pollution rates. But Shared Mobility cannot sustain this change by itself, there is still the issue of the integration of this transportation option to the mobility environment through multimodal connections: from shared modes to public transit or other modes. For these reasons, the purpose of this work is to explore how Shared Mobility can be integrated as a multimodal option for urban mobility, taking into consideration the MaaS paradigm, and which could be the challenges to implement this alternative solution.

Chapter 2: Research Objective, Methodology and Framework

Research Objective

Shared Mobility and Mobility as a Service (MaaS) are new concepts that are just penetrating our society and have not been completely understood or defined yet. This work consists on an exploratory research based on the extant literature about those concepts and cases of implementation of them in urban mobility systems. Considering this, the objective of this work is twofold. First, it aims to analyze the potential role of Shared Mobility within the Mobility as a Service (MaaS) paradigm, as a multimodal option for urban mobility. Second, it aims to identify possible challenges or barriers faced in the attempt of integration of Shared Mobility as a multimodal option within the MaaS paradigm.

Research Question and Approach

Keeping in line with the exploratory purpose of this work, the research question can be defined as: What is the role that Shared Mobility can play within the Mobility as a Service (MaaS) paradigm and how can it be an option for multimodal connections? What are the possible challenges and barriers of this integration?

In order to answer the research questions, the methodology used was through the qualitative analysis of implementation cases in which different shared modes have been integrated as a multimodal option in different European cities. First, a review of the key concepts involved (Shared Mobility and

Mobility as a Service) was performed. Then, 4 cases of implementation were selected and presented in order to explore how Shared Mobility is currently being used as a multimodal transportation option in different European cities. Finally, an analysis over the cases was performed, identifying the role of Shared Mobility in the multimodal integration, and highlighting possible barriers/challenges that can be faced during the integration.

Literature Review

A literature analysis of the core topics concerning the research question (Shared Mobility and MaaS) was performed and based on it, the key dimensions of analysis were identified. This literature review was conducted using various sources of information, as electronic journals, white papers and research reports from organizations related to the topics, and online articles. The main topics addressed for Shared Mobility were: Definition and Key Characteristics, Classification and Main Stakeholders. The main topics addressed for Mobility as a Service were: Definition and Key Characteristics, and Operating Conditions.

Implementation Cases

An online research of how Shared Mobility is currently being integrated in different European cities was performed, from both primary and secondary sources (more detail in Chapter 5: Implementation Cases). A first filter was applied to select only those cases in which shared modes were being integrated as a multimodal option for urban mobility. The cases were selected according to the amount of information available, both from websites of the stakeholders involved on the projects and from third party articles and reports. The cases were selected in order to cover different ways of integration, both in terms of the shared mode involved and of the way the shared mode is integrated to a multimodal system. To accomplish this, 4 cases were selected:

- **Mobility Stations (Leipzig, Germany)**: A public initiative to integrate MaaS in public transport stations to facilitate urban mobility (including shared modes as car-sharing and bike-sharing, and other sustainable features as e-charging stations).
- **UbiGo (Gothenburg, Sweden):** A private initiative (with public partnership) pilot program to promote MaaS as an alternative for citizens' urban mobility (including shared modes as car-sharing and bike-sharing).
- **SMILE and WienMobil (Vienna, Austria):** A public initiative pilot program to promote MaaS as an alternative for urban mobility (including shared modes as car-sharing and bike-sharing, and other sustainable features as e-charging stations) and a fully operative MaaS system created as a consequence of the good results of the pilot.
- **CHUMS Project (Toulouse, France)**: A public initiative to integrate carpooling as a multimodal mobility solution in specific business areas of the city.

The first three cases (Leipzig, Gothenburg, and Vienna) involve the same shared modes (bike-sharing and car-sharing) within a MaaS platform system. The three of them were selected to bring more evidence to the study, especially because they differ in some important points that may imply different consequences, or bring different kind of information, for the final analysis:

- The Leipzig case is a public initiative (of the municipality and the public transport agency) as part of their public administration program. Similarly the Vienna case, which pilot was an initiative at national government level, then handed to the public transport agency to develop the fully operative system. On the other hand, the Gothenburg case was born as a private initiative (in collaboration with public entities as the municipality and the public transport company), developing a model not intended to be limited to a single region, but to be exported to other cities if successful.
- The Leipzig case has in the core of the project the physical integration of different transport alternatives, in form of Mobility Stations, contemplating also a supportive digital platform. On the other hand, the

Gothenburg and Vienna cases are purely about the digital platform integration of information, booking, and payment, with some side efforts of physical integration.

- In the Leipzig case, Mobility Stations were planned and implemented in 2015 without contemplating a pilot program, while the other two cases did. The Gothenburg case is about a pilot program (UbiGo) in that city with a certain number of participants, and a fully operative implementation is planned for 2018 expanding also to Stockholm. Finally, the Vienna case contemplates both a pilot program (SMILE) involving a certain number of participant, and a fully operative MaaS system already implemented in June 2017 (WienMobil).

These MaaS platform systems do not include other shared modes as ride-sharing or ride-sourcing. Even in other cases found during the initial research, this kind of MaaS mobility platforms didn't include ride-sharing as an alternative mode within the system, probably because of the complexity of the interactions needed within the platform to properly operate this kind of modes. For this reason, the third case (Toulouse) was included to show how ride-sharing or carpooling can be also integrated as a multimodal option for urban mobility.

Research Framework

The research framework of this work is practical. It means it is formed by the accumulated practice knowledge of practitioners and administrators, summed to the findings of previous research. This work explores Shared Mobility as a potential multimodal solution under the MaaS paradigm to reach a more sustainable mobility environment, and so the dimensions of analysis are those relevant issues contained by both concepts (Shared Mobility and MaaS). These relevant issues are mainly the different shared modes and its particular operational differences, the different actors involved and the role they can play within the integration of shared modes as a multimodal solution, and the conditions of operation of MaaS. These topics will be further developed in the next two chapters (Chapter 3 and Chapter 4).

Chapter 3: Shared Mobility

Definition and Key Characteristics

Shared mobility is part of the so called sharing economy, one of the most significant global socio-economic developments over the past decade (Frenken, 2017). Even if it's hard to give an exact definition of this concept – due to the variety of ways in which the term is used in practice (Schor, 2014) – the sharing economy basically consists in companies and consumers using online platforms to offer their idle goods for a temporary access for free or a fee.

Under this umbrella of the sharing economy, shared mobility is defined as the shared use of a vehicle, bicycle, or other mode which enables users to gain short-term access to transportation modes on an "as-needed" basis (Shaheen et al., 2015). From this definition it is possible to identify two key concepts that determine the innovativeness of this new kind of mobility:

- Shared Mobility offers access rather than ownership.
- Vehicles are accessed on an as-needed basis.

Through access rather than ownership, users avoid investment cost and responsibilities – as maintenance, parking, insurance, or fuel charging – related to ownership, making transportation more accessible to people. Also, the as-needed demand modality allows that the access to vehicles is done only when needed, meaning that when a user stops using a vehicle, it is immediately available for another user. This way, high vehicle idle times related to private ownership are significantly reduced.

Nevertheless, there is a lack of consensus regarding the boundaries of what is embraced by the term "shared mobility". While one perspective is broad enough to include, for instance, shuttle buses, a contrasting perspective would emphasize the importance of ICT as an intermediator between offerors and users (Le Vine and Polak, 2015).

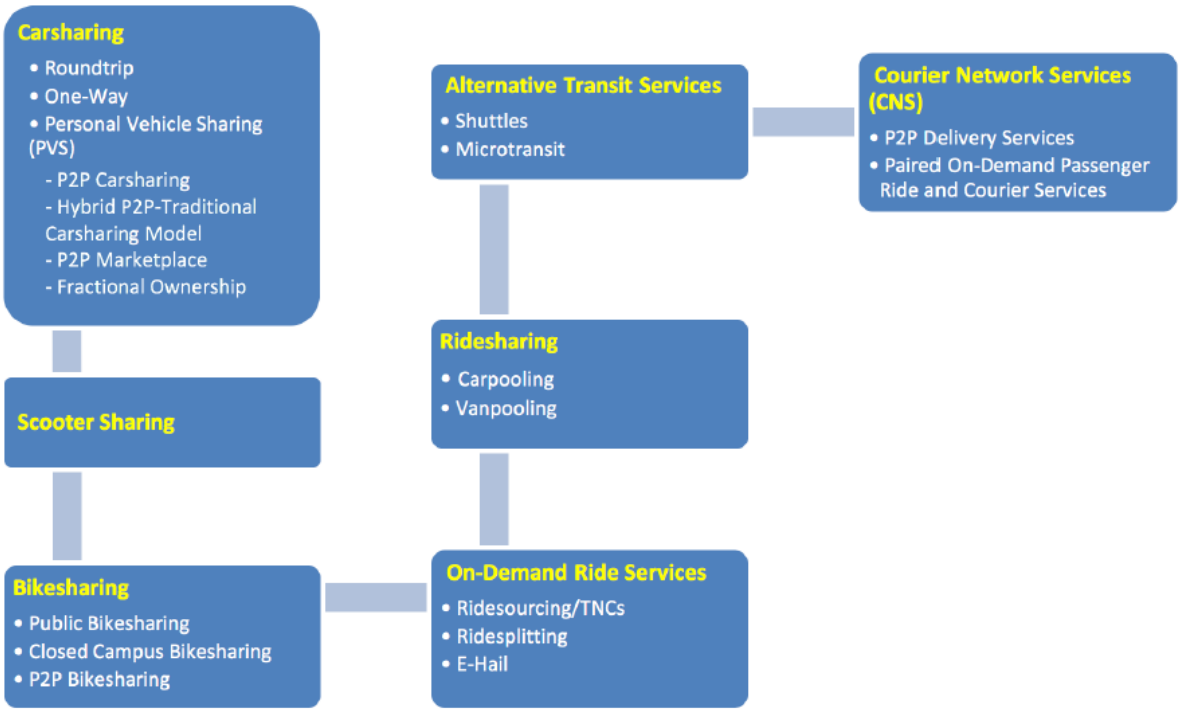

Figure 1. Key Areas of Shared Mobility (UC Berkeley's TSRC, 2015).

Classification

Shared mobility services include various modalities which differ one another depending on the vehicle involved, or even by the element that is being shared – the vehicle itself or a spot inside a vehicle.

Based on a report prepared by Shaheen and colleagues (2015) for the Transportation Sustainability Research Center (TSRC) of the University of California Berkeley and in collaboration with the California Department of Transportation, the term shared mobility includes various forms of car-sharing, bike-sharing, scooter-sharing, ride-sharing, and on-demand ride services. The term may also include other secondary or alternative transit services, such as paratransit, shuttles, and private transit services (such as shuttles or microtransit). It could even include commercial delivery vehicles providing flexible goods movement, also referred to as Courier Network Services (CNS), which provide for-hire delivery services using an online platform to connect couriers using their personal vehicles, bicycles, or scooters with freight (as packages or food).

Car-sharing

Car-sharing is a Shared Mobility mode in which users gain the benefits of private vehicle use without the costs and responsibilities of ownership. There are different car-sharing service models, such as roundtrip car-sharing, one-way car-sharing and personal vehicle sharing (PVS).

Roundtrip car-sharing was the earliest car-sharing service model. In this kind of system, users have hourly access to a fleet of shared vehicles and have to return the vehicle to the same location from where it was picked up.

One-way car-sharing, also known as free-float or point-to-point car-sharing, allows users to pick up the vehicle at one location and drop it off in another. This kind of systems offer more flexibility than roundtrip car-sharing and is more suitable for enhancing first/last mile connectivity.

Personal vehicle sharing (PVS), also known as peer-to-peer (P2P) car-sharing, is the employment of privately-owned vehicles made temporarily available for shared use by an individual or members of a P2P company, which offers the platform to make possible the interaction between offerors and users.

Bike-sharing

Bike-sharing systems allow users to access bicycles on an as-needed basis generally from a network of stations, which are usually concentrated in urban areas. The operator is responsible for bike maintenance, storage, and parking costs. ICT development has also allowed the emergence of free-float bike-sharing systems, in which bikes can be picked up and dropped off at any point of a certain area – a geo-fenced area – and can be booked and unlocked through a smartphone app. Bike-sharing may also include P2P systems, enabled through the intermediation of a third-party which provides the platform and application.

Other classification proposed by Shaheen and colleagues (2015) identifies three main types of bike-sharing systems: public bike-sharing, closed-campus bike-sharing, and P2P bike-sharing. Most bike-sharing systems are public, with anyone able to access a bicycle for a nominal fee (with a credit/debit card on file). Closed-campus bike-sharing are increasingly being deployed at university and office campuses, and bicycles belonging to these systems are only available to the particular community they serve. P2P systems are other kind of system in which bike owners can rent out their idle bikes for others to use.

Ride-sharing

Ride-sharing facilitates connections between drivers and passengers with similar origin-destination pairings in order to share rides. This mode includes carpooling and vanpooling. According to the definitions of the Federal Highway Administration (FHWA) of the USA, vanpooling is classified as a

grouping of 7 to 15 persons commuting together in one van, while carpooling involves smaller groups (less than 7 persons) travelling together in one car.

There are 3 main categories under which ride-sharing can be classified: acquaintance-based, organization-based, and ad hoc. Acquaintance-based is the most common ride-sharing mode and it consists of carpools formed by people who are already acquaintances, as members of the same family or coworkers. It doesn't require a digital platform to arrange the carpooling, as the carpoolers can communicate and organize the details of the trip by themselves. Organization-based ride-sharing, on the other hand, consists of carpools arranged through a third party platform, and require participants to join the service either through membership or by visiting a website. Finally there is ad hoc ride-sharing, a more spontaneous modality that involves other unique forms of ride-sharing, including casual carpooling, also referred to as "slugging".

On-demand ride services

On-demand ride services include ride-sourcing or transportation network companies (TNCs), ride-splitting within these TNC services, and e-Hail services for taxis. Ride-sourcing – also referred to as TNC services, ride-hailing and ride-booking – are ride services that use smartphone apps to connect community drivers with passengers. It differs from ride-sharing mainly by the driver function: while in ride-sharing the driver would do the trip anyways even if there are no other riders to share the trip with, in ride-sourcing the driver performs the trip only to serve the riders and get an economic compensation from that. Within the same kind of service, it is possible to identify also ride-splitting, which consists in the split of a TNC-provided ride between users taking a similar route. Finally, there is e-Hail services: a response of the taxi industry to the rise in TNCs. It basically on the reservation of taxis by an "e-Hail" phone application provided either by the taxi company or a third-party provider, which helps decreasing the wait times for users and making its service levels more comparable to the TNC's.

Impacts and Benefits

Shared mobility can bring a number of environmental, social, and transportation-related benefits to the cities where implemented. Several studies have documented the reduction of vehicle usage, ownership, and vehicle kilometers traveled (VKT) (UC Berkeley's TSRC, 2015). Cost savings and convenience are also frequently cited as reasons for shifting to shared modes.

As for car-sharing, according to a study performed in 2014 by the UC Berkeley's TSRC on a sample of 9.500 people who participated in car-sharing programs in the US and Canada, 25% of members sold a vehicle due to car-sharing, and another 25% postponed purchasing a vehicle. This study also concluded that 1 car-sharing vehicle replaces 9 to 13 vehicles among car-sharing members because they sold their vehicle or postponed purchasing one. This reduction in the number of vehicles results in reductions in vehicle kilometers traveled (VKT) of between 27% and 43%, as well as reductions in greenhouse gas (GHG) emissions of between 34% and 41%. It was also reported that, after joining car-sharing, monthly household savings per US member was between 154 and 435 USD.

Another study by the TSRC, completed in 2014 after two years on a sample of around 6.200 bike-sharing users in the US, Canada and Mexico, documented that bike-sharing members in large cities rode the bus less, while in small cities bus ridership increased – attributed to the fact that bike-sharing improves the access to/from bus stops. Rail usage had similar results, increasing in smaller cities but decreased in larger cities, due to faster travel speeds and cost savings from bike-sharing. Finally, the study reported that 50% of the bike-sharing members reduced their personal automobile usage, and around 6% of them sold or postponed a vehicle purchase.

As for ride-sharing, one of its main and obvious benefits is the reduction of the driver costs, as the costs related to gas or tolls are usually split among the riders, and the reduction of vehicle usage, as the trip that different riders would do in different cars is now performed using only one. According to Dorinson and colleagues (2009), the savings of flexible carpoolers can rise up to two-thirds of the costs of commuting alone in a single-occupancy vehicle.

Main Stakeholders

As any other system, shared mobility involves the participation and interaction of different stakeholders, each of which have a specific role to play in order to make the system work. Among the main involved actors in shared mobility it is possible to identify: users (actual and potential), operators, public entities and regulators, and transportation scientists.

Users

Users are those people who are members of a shared mode platform and/or use shared vehicles for their mobility needs. Potential users are all those people who are legally allowed to drive or to use a shared service. They play a fundamental role as they are the ones that are expected to spread the shift of perception of mobility, from the ownership paradigm to the new one based on access to satisfy their mobility needs.

Users of Shared Mobility entrusts this kind of modes for their mobility needs, as public transportation cannot always meet the routing or schedule of their trip plan. Nevertheless, users may expect a comfortable mobility experience with shared modes in order to desist owning a car.

According to some studies made with samples of users in the USA, the average user of car-sharing and bike-sharing is more likely to be Caucasian, male, between the ages of 20 and 35, and well educated compared to the general population (Shaheen et al, 2014) (Dill et al, 2014).

Potential benefits for Shared Mobility users can be economical or even a healthier lifestyle. According to the research report 188 of the Transit Cooperative Research Program (2016), the more people use shared modes, the more likely they are to use public transit, own fewer cars and spend less on transportation overall. More specifically, “Super-sharers” – people who routinely use several shared modes, such as bike-sharing, car-sharing, and ride-sourcing – save the most money and own half as many household cars as people who use public transit alone.

Shared Mobility Operators

Shared mobility operators are the companies that offer the range of different kinds of shared mobility services to the users. They can be either private companies or private-public partnerships, so their needs can go from purely monetary (making profit), to offering citizens alternative mobility services.

It is possible to classify the operators according to the kind of business (P2P or B2C). In P2P services, the operator offers the digital platform in order to intermediate the relationship between the members who offer the use of their own vehicle and the users. In these cases operators may not own a fleet of vehicles. In B2C services, the operator owns the fleet of vehicles and is the full responsible of all the services offered (vehicles maintenance and fueling, insurance, digital platform, and others).

Public Entities

Public entities are all those public organizations – as municipalities, regional governments, transportation authorities, regulators, etc. – that may influence the environment of urban mobility. They play a fundamental role defining the context in which shared mobility services will operate in a certain territory. Their main need and goal is to ensure the wellness and life quality of their people. Urban mobility is a part of this problem, and for this reason public entities have to manage problems as air pollution, congestion on the streets, or even parking availability. Local and regional governments become a key public partner of shared mobility operators because of their role in transportation planning, public transportation and parking policy.

In a report prepared by Shaheen and Cohen (2016) for the US Department of Transportation, they identify the main areas of interest regarding the role of public entities and regulators on the shared mobility context. This areas are: Health and Safety, Taxation, Insurance, Parking and Rights-of-Way, Signage and Advertising, Urban Planning Processes, Data Sharing and Privacy, Accessibility and Equity, and Multimodal Integration.

Regarding to Health and Safety, local governments and public agencies are in charge of the creation of regulations on shared mobility operators established in order to protect the wellness of shared mobility users. In addition, customer protection laws defend customer interests and ensure fair trade practices, open competition, and accurate information in the marketplace. Some examples of these laws impacting shared mobility are helmet laws (for bike-sharing services), insurance law (as minimum levels of insurance for P2P services), for-hire driver laws (requiring driver physical tests and minimum insurance for taxis and TNCs), pricing regulations (for consumers to receive an estimated service cost and receipt for services), and access laws (protecting access for special needs populations).

Taxation is another role of public entities. It is a complicated issue due to the unclear definitions and service models among shared mobility services. Similarities between service models of ride-sourcing and taxis, or between car-sharing and rental cars, have made difficult to define which kind of taxes must be declared and payed in the different services. Questions over if drivers should declare and pay taxes, how much, and what taxes to pay have not been clearly answered in many jurisdictions (US Department of Transportation, 2016).

Insurance policies to protect both the users and the assets are another role for local governments. They have to set insurance limits and requirements for the different shared mobility modes. This is a key problem, especially for P2P vehicle sharing and on-demand ride services, as in these business models shared mobility operators provide just the platform to allow the interaction between offeror and consumer, and hence the operator does not have a direct interaction with users during the service provision.

Regarding to the issue of allocation of Parking and Rights-of-way, local governments have to define how public spaces will be used, enabling shared mobility services operate in a certain area. This is a key issue especially for car-sharing and bike-sharing operators, which need physical space for the location of their stations (in station-based models), or special parking policies (for free-float systems) for the allocation of their vehicles.

Other roles of public entities are related to Signage and Advertising (set of policies regarding street markings, wayfinding signs, pick-up and drop-off point signalization, and others), Multimodal Integration (how to determine the role of public transit operators in advancing multimodal integration with shared modes), Planning Processes (how to incorporate shared mobility into local planning processes, such as land use and transportation plans), Data Sharing, Privacy, and Standardization (how to develop a balanced data system which balances data sharing with privacy among individuals, companies and public agencies), and Accessibility and Equity Issues (how to address trends in shared mobility related to accessibility to the services, including how public entities and shared mobility operators address equity).

A summary of the above mentioned roles of public agencies within the context of shared mobility can be found in Table 1.

Transportation Scientists

Transportation scientists are all those academics and researchers studying matters related to mobility and transportation. As shared mobility is a relatively recent phenomenon, it's in constant development and new challenges continue to appear. Researchers and transportation scientists play a fundamental role on this development, both for matters directly related to the shared modes – as station location and capacity for bike-sharing and car-sharing modes, fleet dimensioning, rebalancing, pricing incentives, and inventories (Laporte et al., 2015) – and for matters related to the integration of these shared modes to the transportation system of the cities.

PUBLIC ENTITY ROLE	DESCRIPTION
HEALTH, SAFETY AND CONSUMER PROTECTION	Local governments and public agencies establish administrative regulations, ordinances, and laws that protect the wellness of users.
TAXATION	Tax incentives and taxation on shared mobility, such as rental car excise taxes, sales taxes, and commuter tax breaks.
INSURANCE	Insurance limits and requirements for shared mobility modes, issue particularly important among P2P vehicle sharing and on-demand ride services.
PARKING AND ACCESS TO RIGHTS-OF-WAY	Management of on-street curb space for shared modes, including equity issues pertaining to the use of public space for private businesses or non-profit purpose.
SIGNAGE AND ADVERTISING	Management of signage and advertising for signalization and promotion of shared mobility modes within the city.
MULTIMODAL INTEGRATION	Determination of the role of public transit operators in advancing multimodal integration with shared modes.
PLANNING PROCESSES	Incorporating shared mobility into municipal and regional planning processes, such as land use and transportation plans.
DATA SHARING, PRIVACY, AND STANDARDIZATION	Development of best practices that identify data standards and balance data sharing (open data) and privacy among users, companies, and public agencies.
ACCESSIBILITY AND EQUITY ISSUES	Management of trends regarding accessibility to shared modes, including how public agencies and shared mobility operators define, measure and address equity.

Table 1. Summary of public entities' roles in the context of shared mobility.

Chapter 4: Mobility as a Service (MaaS)

Although shared mobility arises as an innovative kind of transportation service that can help to solve the first and last mile problem in a more sustainable way than private car ownership, there is another problem that must be addressed: the easiness of the intermodal connections during the whole individual trip. In the last few years a new concept has been introduced in the field of urban mobility attempting to approach the consumers' mobility problem as a need that has to be satisfied as a whole. This concept is known as Mobility as a Service (MaaS), also referred to as Transportation as a Service (TaaS), and it consists on the integration of different transportation modes (among which it is possible to include shared modes) into a single mobility service, to make it easier for users to do multimodal connections through integration of information and payment.

Definition and Key Characteristics

Mobility as a Service (MaaS) is defined by the Maas Alliance (2015) as the integration of various forms of transport services into a single mobility service accessible on demand. This concept stands for buying mobility services as packages based on consumers' needs instead of buying the means of transport. Through these systems, consumers can buy mobility services provided by the same or different operators by using a single platform with a single payment channel, instead of multiple ticketing and payment operations. MaaS platforms usually offer an intermodal journey planner (providing a recommendation of combinations of different transport modes, including car-sharing, bike-sharing, public transport, taxi, and others), a booking system, easy-payment, and real time information (Kamargianni et al., 2015).

The objective behind MaaS is to create integrated and seamless mobility to satisfy users' mobility need. To accomplish this, MaaS is based on three main elements that help providing seamless intermodal trips (Kamargianni et al., 2016):

- Payment integration: when one smart card or ticket can be used to access all the modes involved in the service and only one account is charged for the use of those services.
- Mobility package: when customers can pre-pay for a specific amount (in time or distance) of a combination of mobility services.
- ICT integration: when there is a single application or online platform that can be used to access information about the modes.

Payment integration is the most basic integration way and is usually achieved through the use of smart card technology. This kind of technology is already being used in a large number of cities worldwide for public transport, and many of them show evidence of the popularity of this payment method among users. The use of smart card technology is globally in constant grow (Smart Card Alliance, 2017).

Mobility package integration is the mobility tool that allows customers to pre-purchase usage of various transportation modes for a longer period of time as one product. The idea behind these mobility tools is that consumers can use the range of transportation modes with low or even zero marginal cost, by paying a fixed upfront cost.

ICT integration in transport is generally referred to a unique and centralized platform that assembles information of various transportation modes. It includes functions such as journey planning, booking, and real-time information, in order to facilitate and support users throughout the different stages of the trip ("pre-trip", "wayside" and "on-board").

Operating Conditions

Li and Voege (2017), in their work about challenges of implementation of MaaS, identify some basic conditions that are required for the implementation and operation of a MaaS service, despite different business models. These requirements are: single identity for a user, open data and open payment methods from various transport modes.

Operating MaaS requires a single identity for every user to travel with different modes, in order to keep track of how each traveler uses the different transport modes and integrate this data to issue a single bill to a single user. Open data and open payment methods are also fundamental to create a MaaS system among the different operators of various transport modes. If a transport operator is not willing to use third party's payment to buy its tickets or to allow a third party to sale its tickets on their behalf, the services of the operator cannot be included in MaaS.

ICT development as smartphone applications is a key factor to facilitate the achievement of these requirements. People often forget their public transport cards or documents, but they rarely forget their mobile phones (Sochor et al., 2014). Therefore, for a MaaS system it is pretty convenient to use smartphones as people's new "ID" to travel through different transport modes.

Considering the basic conditions mentioned before, Li and Voegue (2017) also identify some conditions which must be met in order to develop and operate MaaS in a specific city. These conditions are summarized as below:

- A wide range of transport modes must be available in the city;
- Majority of the transport operators must be willing to open their data (including real-time data) to a third party;
- Majority of the transport operators must allow a third party to sell their service;
- Majority of the transport operators must offer e-ticket or e-payment to access their services.

As multimodality is a key concept for MaaS, a city would be adequate to operate MaaS only if it offers different transport modes. A city must also have adequate public transport services – as it is the core transport mode of MaaS – to allow users to travel in the city easily without having to own a car. In other words, public transport must be good enough for users to be willing to move away from car-dependent daily transport.

Traveler information provision has traditionally been a responsibility of the transport operator. Recently, many transport operators are choosing to open their data to allow developers to implement information services. This has a huge impact on traveler information provisions. At a wider level, if a MaaS provider is planning to include a specific transport operator in the service, the provider must access real-time data – for instance, real-time data at each station of a bike-sharing system – in order to include it in the service. It can be foreseen that if MaaS becomes the main travelers' choice, more transport operators would be willing to share their data with MaaS developers to be part of the system.

Another essential condition of MaaS is to use a single account to pay all the transport services. In order make easier for users to pay for their travel, and not to need different cards, different accounts or individual payments, every transport operator part of a MaaS system must be willing to allow a third party to sell their service on their behalf.

The last key success factor of MaaS is that smartphones can be used to access various transport modes. This means that every operator of those transport modes must allow various forms of e-ticket or e-payment. This way, all payments can be done through the MaaS app. This could imply additional investment into infrastructure to make it possible to activate the service through the MaaS app – for instance, public transport provider must have the proper infrastructure to allow users to pass the physical barriers by scanning their smartphones.

The following figure summarizes a checklist to verify a priori if a city meets the requirements in order to implement MaaS:

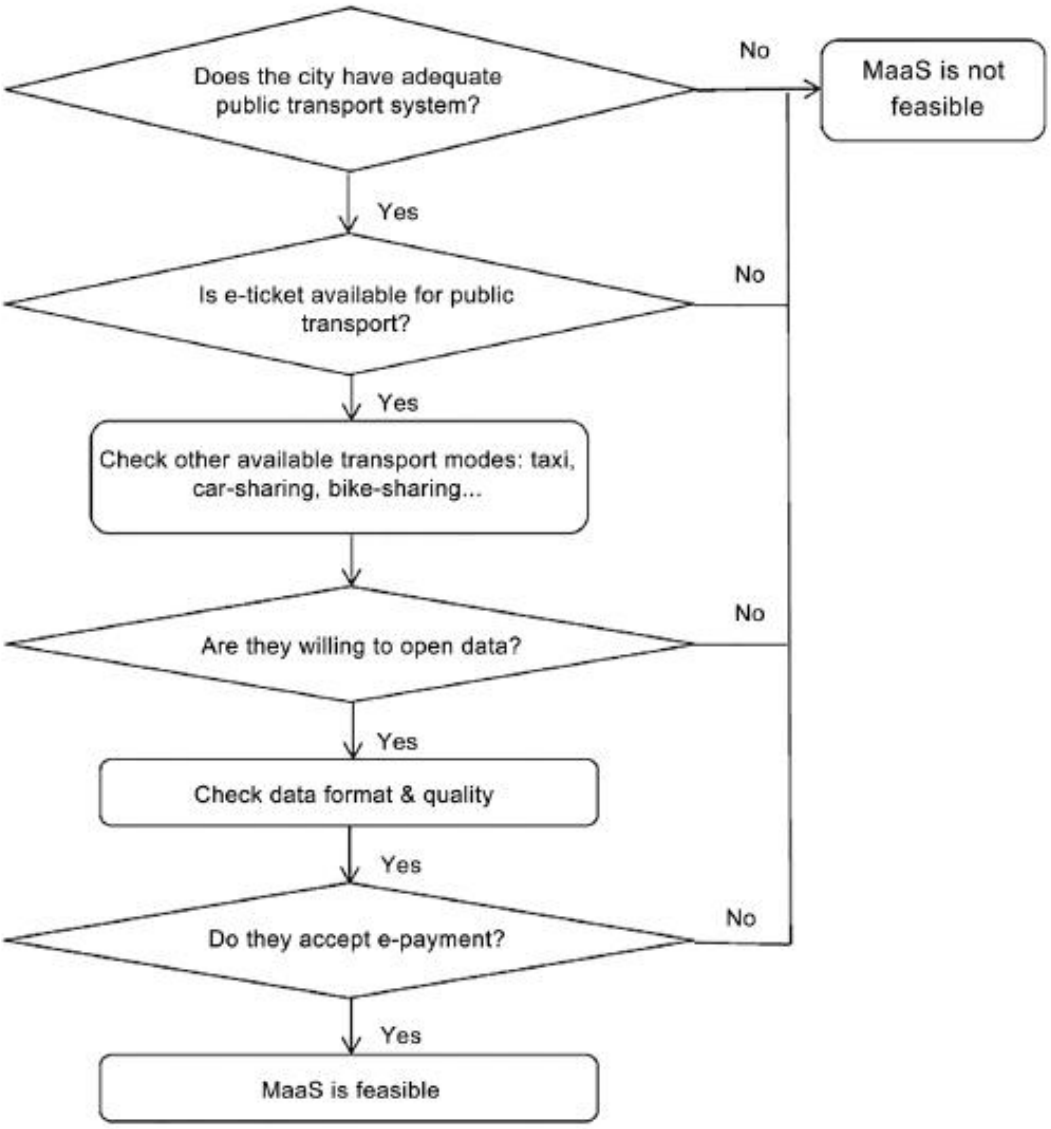

Figure 2. Check list of operating MaaS in a specific city (Li and Voege, 2017).

A MaaS system may be initiated by the local authority of a city as an instrument to make urban mobility in the city more sustainable. However, MaaS may also be operated in a city without official support of the local authorities when the basic conditions mentioned above have been met.

Chapter 5: Implementation Cases

In the present chapter, 4 cases of implementation of shared modes as a multimodal option for urban mobility will be presented.

Case 1 shows how City of Leipzig, in Germany, implemented a system of Mobility Stations to integrate public transportation stops with other modes as car-sharing, bike-sharing, taxi, and other mobility features as electric car charging stations and bike parking, complemented with a mobile app (Leipzig Mobil) as MaaS platform for information, booking and payment of the mobility service. The information needed was taken from official reports of City of Leipzig, as well as from secondary sources as press articles and partners websites.

Case 2 presents a pilot program developed in Gothenburg (Sweden) by UbiGo: a mobile MaaS app which offered to the participants of the pilot the possibility to pay a subscription in order to have a certain amount of credits to use in mobility services as public transportation, car renting, bike-sharing, car-sharing and taxi, with very successful results. Information to develop the case was taken from the UbiGo website and articles from the Chalmers University of Technology (project member), as well as from secondary sources as the International Transportation Forum and Fluidtime (IT developer).

Case 3 presents a pilot program launched in Vienna (Austria) of a mobile app very similar to the previous case. This app was called SMILE and it received many awards thanks to the good results it had. Case 3 presents also another MaaS app, created as a consequence of the good results of the pilot, but this time directly controlled by Wiener Linien, the public transport operator. The information to develop this case was directly taken from both the SMILE project and Wiener Linien websites.

Finally, Case 4 presents a project called CHUMS in Toulouse (France) which integrated as a multimodal alternative for urban mobility a shared mode not included in the previous cases: ride-sharing (carpooling). Information was retrieved directly from the CHUMS project webpage, as well as from a secondary source (Eltis, the European urban mobility observatory).

Case 1: Mobility Stations as support for intermodal connections in Leipzig (Germany)

The context

Leipzig is a city located in the northeastern region of Germany. It has experienced a significant population growth in the last years – 60.000 inhabitants growth over the past 12 years –, reaching a number of about 570.000 inhabitants as of February 2016. Despite being the 10th German city in number of inhabitants and the 8th in land area, Leipzig has the second largest public transportation network following Berlin. Its cycling infrastructure is also noteworthy, having grown almost fourfold in the last two decades, reaching over 430 km of bicycle lanes and paths (EcoMobility Alliance, 2015).

Leipzig joined the EcoMobility Alliance – a group of enthusiastic local governments with a common goal: to create and implement urban mobility strategies that prioritize people and the environment – in May 2016.

As one of the fastest growing cities in Germany, there is a high risk of congestion of traffic system and losing the high quality of life standard due to

the air and noise pollution. The narrowness of the streets in a compact city center makes even harder to overcome this threat of growth, with no possibility to increase space for car traffic.

The City of Leipzig identified the increase of modal share of environmental friendly modes of transport and the change from car ownership to car use as key aspects for sustainable growth, and so implemented in 2015 a program to promote car-sharing and bike-sharing schemes as an integrated part of the public transport system for intermodal trips: the so called Mobility Stations (or Mobilitatsstationen in German language).

The project and the actors involved

Mobility Stations were devised to support the changing between modes of transport. The basic idea is to integrate all modes of transport at one location in order to ease multimodal connections. Among the elements integrated on the Mobility Stations there are car-sharing, bike-sharing, electric car charging stations, public transportation stops, taxi and bike parking.

The basic idea was introduced by the City of Bremen within a knowledge exchange project between the cities of Bremen, Nurnberg and Leipzig. The main reason for proposing this kind of project was the lack of a legal framework for car-sharing in public space. A first development of the Leipzig model by the Office for Traffic Planning and Road Construction started in 2012, including the first potential locations for the Mobility Stations.

Figure 3. Transport providers in the Mobility Stations system.

Leipziger Verkehrsbetriebe (LVB) – Leipzig's municipal transport operator – adopted the planning, coordination and realization of the project in 2013. The project also required the involvement of a car-sharing company (teilAuto), bike-sharing company (nextbike), which provided their services and disclosed data to make the digital integration possible. The total cost was of EUR 750.000 and was partly financed with European Funding (ERDF: European Regional Development Fund).

Mobility Stations' efficiency to integrate car-sharing and bike-sharing with public transportation doesn't lies only in the physical location of shared mobility stations beside public transport stops, but also in a digital integration of the different modes. LVB launched in 2015 'Leipzig Mobil', a mobility platform that connects Leipzig's shared and private transportation options – public transport, car-sharing, and bike-sharing among them – into one single platform. A panel with touch screen for better visibility is set on each station, with a display for information – as city map, routes, or available vehicles – and booking via RFID Card. The system integrates all transport modes, so with one card is it possible to book car-sharing cars and bike-sharing bikes together with public transport with a combined invoice by the public transportation company (LVB).

Figure 4. Mobility Station panel (left) and Panel's screen display example (right) (City of Leipzig, 2015).

‘Leipzig Mobil’ platform is not limited only to the Mobility Station panels, but it also contemplates the ‘Leipzig Mobil’ smartphone app for reservations and information service. This allows customers in the city and surroundings to combine their mobility options to suit their requirements at any time and receive one invoice from a single supplier. People can freely download this app, and it doesn’t demand registration to have access to information and maps, or even to buy tickets for public transport directly via the application. Customers must register at a LVB service point to benefit from all services offered by ‘Leipzig Mobil’, and paying a basic monthly fee of EUR 4.90 they can access to book shared cars and bikes via the system. Finally, all trips undertaken using the ‘Leipzig Mobil’ platform are paid at the end of the month.

The ‘Leipzig Mobil’ platform was designed and managed, both in Mobility Stations’ touch screens and smartphone app, by TAF mobile – an IT company specialist in local public transport – using for the design and implementation their tried-and-tested mobility platform easy.GO.

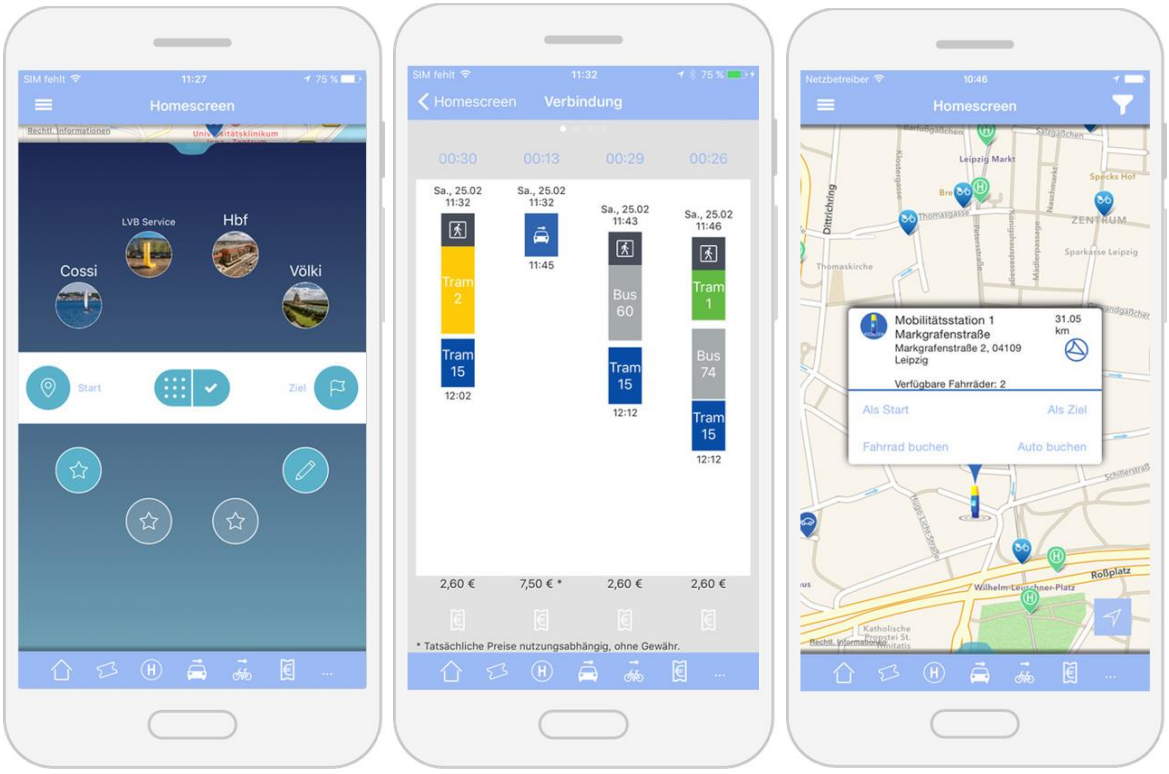

Figure 5. Examples of screen display of the mobile app Leipzig Mobil.

What's next

By the end of 2016 there were 25 stations realized by LVB, and more locations were planned. The involvement in mobility issues transcended to other kind of organizations involved in the city life, as the initiation and funding of a 26th station by a local newspaper company (Leipziger Volkszeitung).

There is no current valid data available for the increase of car or bike-sharing services use, but it's certain that Mobility Stations improve interchange between modes of transport, ease the access for new consumers of shared mobility services, and supports a car independent life style, enhancing mobility as a service rather than private car ownership.

Future plans include the enlargement of the number of Mobility Stations in order to improve access, and the creation of 'light' Mobility Stations, which would have a complete service coverage but without the use of a display panel (booking and information would be app based). Additionally, there are Mobility Points planned with particular service providers, but the same cooperative design. It's intended also to further develop the Mobility Stations platform in order to expand intermodal offers such as connections to taxi companies and airlines, keeping the one-invoice model.

Case 2: UbiGo: A MaaS pilot solution in Gothenburg (Sweden)

The context

Gothenburg is the second largest city in Sweden with about 575.000 inhabitants in 2016. Located on the west coast of the country, it's known for being home to many university students (as the city includes the University of Gothenburg and Chalmers University of Technology) and to the Volvo carmaker company.

The city has over 80km of double track for its tram network, which is the largest tram/light rail network in Scandinavia, and together with the bus network, is the most important public transport mode of the city. The soft ground makes impossible the creation of a subway network, as tunneling is very expensive in such conditions. The city also counts with a commuter rail with three lines connecting to nearby cities and towns.

In order to explore new models for mobility, and as an attempt to integrate already existing mobility services as taxi, car rentals, car-sharing and bike-sharing to complement the public transportation network, Lindholmen

Science Park – a community dedicated to research and development in mobile communication, intelligent vehicles and transport systems, and modern media industry – started the Go:smart project, in collaboration with other partners from the industry, academia, and public sector as: AB Volvo, Commute Greener, Chalmers Technical University, City of Gothenburg, Västra Götaland Region, Västtrafik (regional public transport company), Swedish ICT Viktoria Institute, Swedish Transport Authority, and others. The goal of this project was to develop and test an innovative service that makes it easier and rewarding to use sustainable modes of transport in urban areas (UbiGo, 2017).

Figure 6. Set of partners of the Go:smart project.

The project and the actors involved

To reach the goal for which the project was created, Go:smart created the start-up UbiGo: a MaaS platform which offered a subscription model based on a flexible monthly subscription with an account that is shared among all the members of a household. The idea of the service is to offer an easy and sustainable everyday life without having to own a car. Thanks to the subscription, users could access a variety of transportation modes (including public transport, car-sharing, bike-sharing, taxi, and car rentals) for a certain amount of monthly credits. UbiGo was initially created to run a MaaS pilot program to be developed in Gothenburg in 2014.

The UbiGo pilot program launched in Gothenburg in 2014 involved the participation of 83 households (subscriptions) – 173 adults and 22 children – which payed a monthly subscription to have access to public transport, car-sharing, the city bike-sharing system, car rental, and taxi, as well as 24/7 support. The majority of participants lived in an apartment and worked full-time, had a driver's license (but not necessarily had daily access to a car) and public transport card, and did not subscribe to a car-sharing or bike-sharing system before.

The suppliers selected for the pilot program were Västtrafik (public transport), Sunfleet (car-sharing service), Hertz (rental cars), TaxiKurir (taxi) and JCDecaux (owner of the city's bike-sharing system: Styr & Ställ), which disclosed relevant information and payment system to UbiGo in order to make the digital integration of their services.

Figure 7. Transport providers in the UbiGo system.

UbiGo offered users the possibility to use the service to sign up for a certain number of daily public transport tickets for the month, for instance, or a number of monthly car-sharing credits in the form of hours. If a household had more transportation needs during the month, additional credit could be purchased through the app. In the opposite case, if a household didn't use all the credits by the end of the month, they were able to keep that credit as an extra for the next month. UbiGo also had a rewarding system to promote eco-friendly modes: every time users used this kind of modes, like biking or public transportation, they were awarded points that could be exchanged for transport credit, or even other kind of prizes such as gift cards and concert tickets.

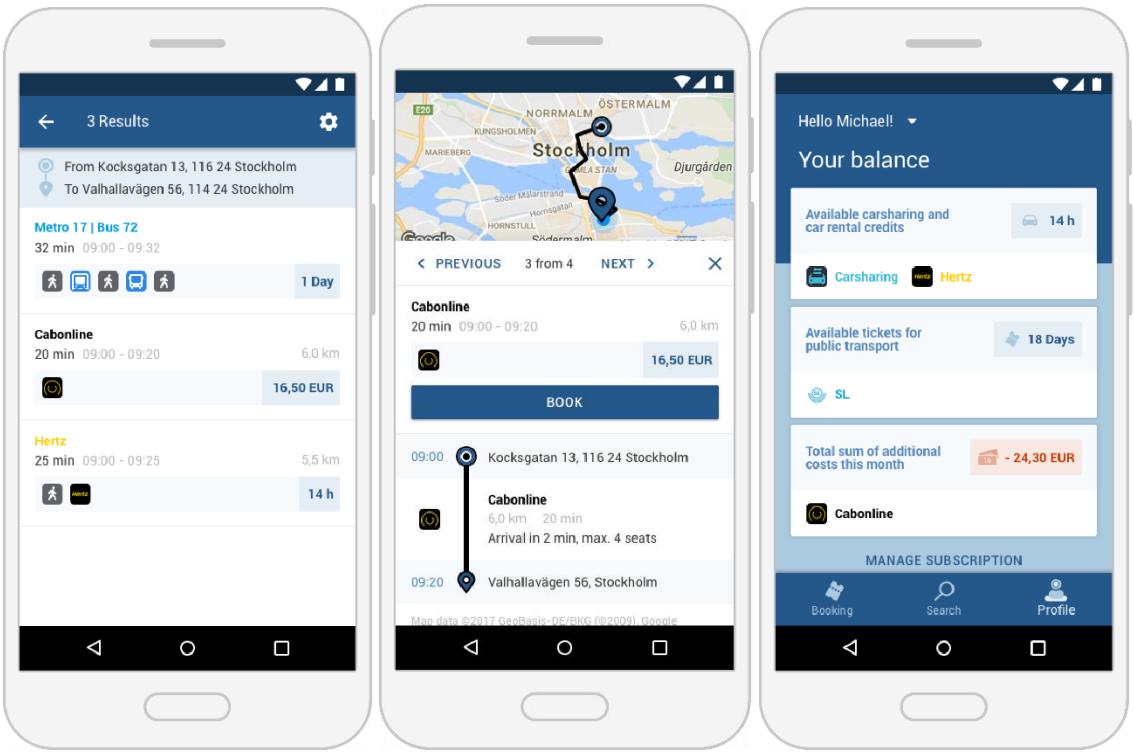

Figure 8. Examples of screen display of the mobile app UbiGo.

The main take away of the pilot program is that people really changed their behavior and were happy with it. Results from the thorough evaluation based on surveys, interviews, travel diaries, focus groups and usage were very positive. None of the households stopped using the service, and a majority of them stated that they wanted to stay as customers (Chalmers, 2016). Results also showed that participants reduced use of private cars. The participants' expectations of convenience and price worthiness were fulfilled. Participants also say that they like the service because it's easier to pay for the travel and they have a better control of expenditures. These good results drove UbiGo to receive the OECD International Transport Forum's award for Promising Innovation in May 2015 (ITF, 2015). This project was applauded by the jury for putting customers' needs at the heart of its approach to reduce car use and specifically noted the good potential for replicability.

What's next

After the end of the Go:Smart project, a group of individuals started UbiGo AB, with the purpose of continuing the service with the existing customer base and expanding it to full service, but challenges with raising start-up capital as well as an unclear role of the regional public transport operator, resulted in the closing of UbiGo AB, and the starting of UbiGo Innovations, with the purpose of redefining the concept.

In collaboration with Fluidtime, an Austrian IT supplier with wide experience in smart mobility, UbiGo is preparing a bigger scale relaunch in Stockholm in 2018. The overall technical implementation of the mobility solution pilot for the relaunch is being designed by Fluidtime.

The new UbiGo pilot will firstly be launched in Stockholm in March 2008, and is scheduled to be fully implemented by the end of 2018, following by the implementation in other cities in Sweden. This new pilot is part of the Horizon2020 CiViTAS Eccentric project (EU funding) with the City of Stockholm as site leader. This relaunch is based on the experiences gained within the successful Go:smart/UbiGo MaaS pilot project in Gothenburg in 2014, since when UbiGo has worked with the public transport community seeking models for the integration of public and private services, along with the refinement of the business model and service concept.

Case 3: The SMILE pilot and WienMobil, MaaS solutions in Vienna (Austria)

The context

Vienna is the capital and larges city of Austria, located in the northeastern region. It's the largest Austrian city with a population of about 1.8 million inhabitants (2.6 million within the metropolitan area). It has an extensive transportation network with a unified fare system that integrates municipal, regional and railway systems. Public transport is provided by buses, trams, 5 underground metro lines (U-Bahn), operated mostly by Wiener Linien. The city also counts with a suburban trains system, operated by ÖBB (Austrian Federal Railways) with more than 50 stations within the city limits.

Having already a very solid public transportation network and looking for further challenges in the ambit of urban mobility and being pioneers in the "future of mobility", a project called SMILE was funded and headed by the Climate and Energy Fund of the Federal Ministry for Transport, Innovation and Technology (BMVIT), as part of the 3rd call of the "Austrian Electric Mobility Flagship Projects" program. Part of the project team there was Wiener Linien (public transport operator) and ÖBB (Austrian Federal Railways), as well as other IT and research organizations.

Figure 9. Set of partners of the SMILE project.

The project and the actors involved

The SMILE project aimed to create a single mobile app that could provide multimodal travel information, payment, and booking. This app would allow users to have access to a variety of mobility services such as car-sharing, bike-sharing, public transport, taxi and parking through an easy-to-navigate mobile interface. This app would also keep users informed about the transportation modes available around their location, and help them select the most efficient route to their destination, providing them at the same time with pricing information, and allowing users to book tickets directly through the app.

After opening the app, users have information about available means of transport in the area around the current user location or any other chosen point in the map. It provides also further information as departure times of public transport at a stop, available rental bikes, etc. For a selected origin/destination trip, the app offers different options and combinations, which can be sorted by mean of transport, time, price, and CO2 emissions. For offers depending on the duration of usage or distance driven (as for taxis or car-sharing) an orientation price is calculated. When a trip is booked, it is automatically reserved and necessary tickets are bought from the providers. For trips depending on the duration of usage or distance driven, the payment occurs after the usage, when the final price is known.

Figure 10. Set of SMILE mobility and routing partners.

At the core of the project team there were Austria's two largest mobility service providers: Wiener Linien and ÖBB. Companies as VAO, AIT (e-mobility) and toursprung (bike) provided the necessary routing information for all routes. Many other mobility providers (see Figure 10) helped also with the disclosure of necessary information to make the system work (information, booking and payment).

The SMILE app was tried in Vienna as a one-year pilot program in 2014, with more than 1000 registered users. Afterwards, all test users were asked to fill out an online questionnaire, in which 75% of them stated that they were content or very content with SMILE. Furthermore, the test users were allowed to send feedback regarding future developments and improvements for the app. Studies of the Technical University of Vienna regarding to the use of different kind of modes showed that the usage of SMILE led to a more environmental friendly mobility behavior: 48% of the respondents stated to use public transportation more often, and 21% reduced the use of private cars. Regarding to multimodality, 26% combined car and public transportation more often, and 26% combined bike and public transportation more often (SMILE, 2015).

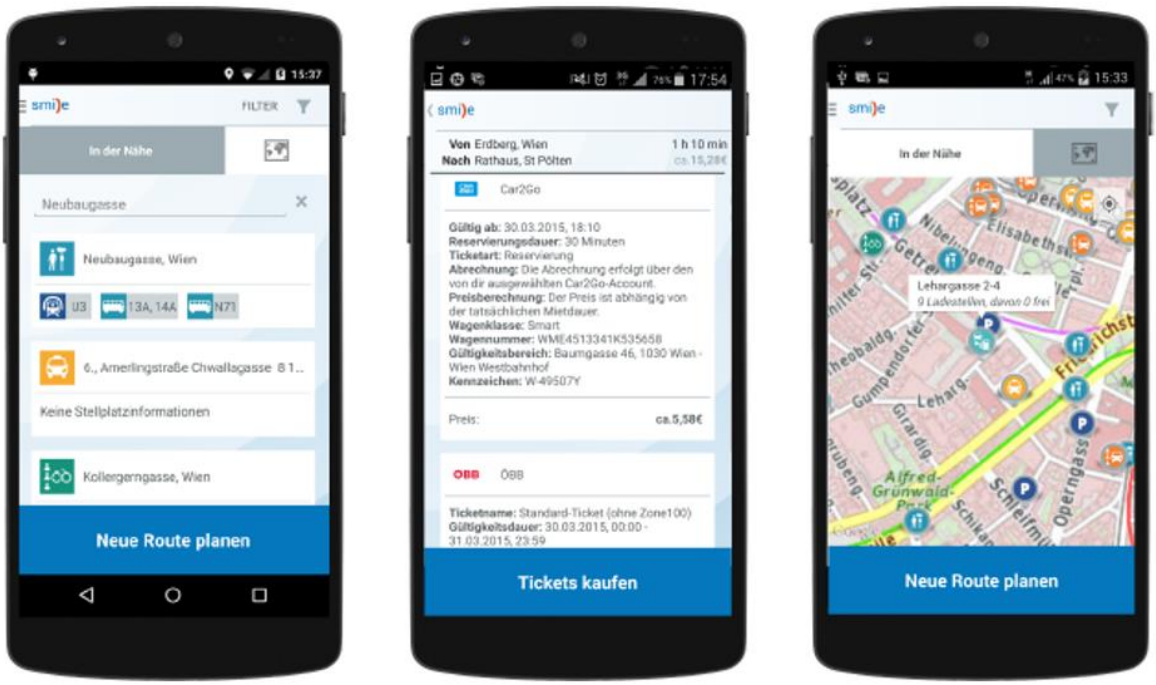

Figure 11. Examples of screen display of the mobile app SMILE.

The good results of this pilot program leaded it to be awarded multiple times. On November 2014, SMILE received the PMA Award from “Projektmangement Austria”, prize that awards project teams that reach outstanding performances and results through project management. SMILE also reached the finals and was one of the three nominated projects in the category “Research. Development. Showing new ways” of the national mobility price (Staatpreis Mobilität), the highest award of the Federal Ministry of Transport, Innovation and Technology. Finally, SMILE was awarded at the UITP World Congress and Exhibition in Milano in June 2015, in the category “Customer Experience”.

What's next

Thanks to the experience gained through the SMILE pilot program and summed to other previous project called WienMobil Lab, Wiener Linien (Vienna's public transport operator) decided to take MaaS to a higher level of integration and make it part of their own transportation system. For this scope, Wiener Linien created the mobile app WienMobil, launched in June 2017 (UITP, 2017).

WienMobil keeps the majority of the features of the SMILE app. Besides public transportation modes (as bus, tram and metro), among WienMobil mobility services there are car-sharing, bike-sharing, car-rental, taxi, parking garages and e-loading stations. Furthermore, WienMobile offers a detailed registration process which allows to further personalize customers' journeys: users can select preferred walking speed, walking distances, and modes of transportation, among many other choices, which enhances the customer-centric nature of the app.

Figure 12. Set of mobility partners of WienMobil.

Case 4: Carpooling as a part of an integrated transport system in Toulouse (France)

The context

Toulouse is a city located in the south of France. It has been lately recognized as one of France's most attractive cities, and has increased its population in about 200.000 inhabitants over the last 10 years, making a total of 1.3 million inhabitants in the metropolitan area, making it the fourth largest city in France. Considering this levels of growth, Toulouse is expected to have around 500.000 additional daily journeys in the next 10 years, which without an adequate strategy could imply many traffic related problems to the actual urban transportation planning of the city.

The city counts with a 2-lined metro network made up of automatic trains, an extensive bus network, and 2 tramway lines. All these systems are operated by the public transport authority SMTC-Tisséo. Toulouse also counts with a railway line connecting 3 stations within the city to the surroundings.

SMTC-Tisséo undertook a 'Mobilities 2025-2030 project' in response to the growing demand for transportation, with three main goals:

- Mobility: to ensure the conditions for sustainable mobility in a context of continuous population growth.
- Attractiveness: to improve access to business and employment areas, while safeguarding their attractiveness.
- Accessibility: to satisfy the demand for travel related to population growth and economic dynamism.

Carpooling was launched as an official transport mode of SMTC-Tisséo in April 2010, by a coordinated set of measures to set up a carpooling website while raising awareness of carpooling.

The project and the actors involved

SMTC-Tisséo developed the Changing Habits for Urban Mobility Solutions (CHUMS) project in order to link carpooling with metro, bus and tram to improve accessibility of the major working hubs of the city. The project's approach is organized in 3 steps:

- Step 1: Deliver a carpooling week to increase awareness and eagerness of staff to try out carpooling, and learn the associated cost savings. Database of registered staff is set up.
- Step 2: Provide Personalized Travel Planning (PTP) services to employees highlighting again the carpooling options, in order to reduce single occupancy trips.
- Step 3: Set up a 'Mobility Jackpot' competition, where each week or month one employee that carpools is awarded a prize which is then communicated across the workplace.

The business areas selected for implementing the CHUMS project were two: PDIE (Workplace Mobility Plan at a Business Area) TOP and Héliopole. The former one comprises of 17 businesses on site, a majority of which are SMEs with more than 500 employees, totaling around 12.000 employees (5.500 public and 6.500 private). The latest one comprises 10 organizations and totals around 2.100 employees on site (300 public and 1.800 private).

The CHUMS measures were implemented in the targeted organizations in two phases between 2015 and 2016.

In the first phase, a Carpooling Week was organized in April 2015. It was a period of communication to promote carpooling among employees commuting trips from TOP and Héliopole business areas. The campaign was promoted under the slogan of 'Drive Collective'. In the second phase, a new Carpooling Week was organized in February 2016 for a widened target covering every company that registered to the carpooling service. For these events, a personalized communication kit was produced (both digital and

paper) for each business center or companies, and used in interacting with the employees. 17 stands and events for employees were organized with the support of mobility advisers from SMTC-Tisséo and mobility managers from the participating companies.

Eight Mobility Jackpot Lotteries were held during the two years of implementation of the CHUMS project. This prizes were targeted to the employees that registered to the carpooling service. Automatic emails were sent to registered carpoolers to participate in the draws, and the winner was communicated by SMTC-Tisséo to the PDIE or participating company contact point that was in charge to promote the result. Finally, SMTC-Tisséo contacted the winner and provided them with a relevant prize (iPad, Smartbox or a gourmet dinner).

Figure 13. Poster of the "Carpooling Week" to promote the jackpot prize.

The third measure of the CHUMP project was the Personalized Travel Planning (PTP), delivered to the employees that requested them through an online questionnaire. SMTC-Tisséo mobility advisors met with the employees, face-to-face or by phone, and offered information consisting of comparative costs between individual car and other transport modes, with the objective of convincing employees to try sustainable transport modes, with special emphasis on promoting carpooling.

What's next

Before the CHUMS project was implemented, there were 504 carpoolers in TOP and 61 in Héliopole. After the first year of implementation, the numbers increased in 10% in TOP and 18% in Héliopole, reaching a total number of registered carpoolers of 4.010. After the second year of implementation, the number of registered carpoolers from the 14 organizations participating in the Carpool Week of 2016 increased from 504 to 669. The total number of registered carpoolers in the SMTC-Tisséo carpool service increased from 4.424 to 4.805.

About the PTPs, in 2015 there were 49 respondents to the questionnaires created by SMTC-Tisséo to define the target of the PTP (prior to the PTP questionnaires) and were considered potentially interested in a PTP. In 2016, there were 156 respondents to the PTP questionnaires, 103 were considered suitable to receive a PTP and 60 PTPs were delivered.

The CHUMS approach helped to unlock potential carpoolers and increasing the number of registered users through the convincing communication campaign added to tailor-made communication materials, thanks to the involvement of the mobility managers of the targeted companies, supported by SMTC-Tisséo, which motivated employees to carpool.

Chapter 6: Discussion and Conclusions

Discussion

The evidence shown by the cases confirms that shared modes can play a role as a multimodal option for urban mobility. The main role that Shared Mobility plays in this context is as a support for the first/last mile around public transport – considering public transport as the backbone of urban mobility – offering a more sustainable transportation service which could replace private ownership of cars and this way help to the reduction of pollution and congestion.

The integration of shared modes as a multimodal solution can take place in two ways: digital or/and physical. MaaS cases show evidence of how shared modes can be integrated digitally to public transportation – and other modes – through a platform that contains real time information, routing services with multimodal alternatives, and offers the possibility to book and pay those different modes all in a single app. On the other hand, Mobility Stations in Leipzig are a good example for physical/digital integration: additionally to the digital integrating app, shared modes are integrated to public transportation by locating Shared Mobility stations or parking (for bike-sharing and car-sharing) right besides public transport stops, to ease even more multimodal connections.

Through the information contained in the implementation cases it is possible also to get some insights of what are the relationships, processes and conditions needed to incorporate shared modes effectively as a multimodal option for urban mobility. With this, some possible challenges and barriers that may be faced while integrating these shared modes can be identified:

- **Funding:** Developing the platform for the MaaS service is not a simple process and costs money and time. Either if it is a public or a private initiative, this kind of projects usually demand external financial sources (as seen in the cases) and it can be challenging to get awarded with funding by some external organization. Developers can leverage options as pilot project funding streams, public-private partnerships, advertising and marketing agreements, as well as other traditional funding sources.

- **Physical space availability:** As seen in the Leipzig case, if the integration of shared modes contemplates the location of car-sharing parking or bike-sharing stations besides a public transit station to create a multimodal environment, physical space barriers could be faced if a certain attractive public transit station doesn't have enough space to be converted into a multimodal station. This could make challenging the search of suitable locations for multimodal stations.

- **Public transport suitability:** A common point among the cities which has successfully implemented and operated MaaS programs is that they have an efficient and well developed public transportation system, which is fundamental for MaaS. Public transport must accept e-tickets and it must have a proper schedule with real time information about the routes status to allow the MaaS system work. Less developed public transportation systems could be a big problem for this kind of integration in other cities.

- **Partnerships and collaboration:** Another key element of the success of the MaaS programs implemented in the cases is the good collaboration among partners involved into the system. Information disclosure from mobility operators to MaaS platform operator is fundamental for the proper functionality of the multimodal trip planning, as well as the integration of the payment system (both fundamental elements for the seamless intermodal trips characteristic of MaaS). These relationships could be challenging if not managed properly, and if not enough importance is given to the benefits of every partner for being part of the MaaS system.

- **Cultural paradigms:** The creation of a multimodal shared modes system needs customers to sustain itself. Even if the pilot programs presented have shown good results in low scale, many people or even societies are still stuck under the “ownership” paradigm. It’s a challenge for all the stakeholders involved to keep promoting “access” over “ownership” to convert more users and make shared modes part of the daily life of societies.

- **Integration of other shared modes:** Car-sharing and bike-sharing are present in all the MaaS platforms presented in the cases, but other shared modes as ride-sharing and ride-sourcing seem not to be considered. The natural answer could be the payment process: while in systems as car-sharing and bike-sharing users pay directly to the operator, in ride-sharing and ride-sourcing users pay to other persons belonging to the system and offering a service. This difference in the payment process, added to legal issues that this kind of shared modes have, opens a challenging question of how these shared modes could be integrated in MaaS platforms in order to further promote sustainable transportation modes.

- **Further levels of integration:** So far MaaS initiatives and academic literature on these topics has focused on how to integrate different mobility modes (among which there are shared modes) into a single mobility service, but it has not been considered to integrate other urban elements. It could be interesting to study the possibility of implementation of shared modes in high traffic urban points, as supermarkets, shopping malls, universities or business centers, having their own car-sharing or bike-sharing fleet, or even a carpool program as the one presented in the Toulouse case, which at the same time could be integrated into a MaaS platform.

Conclusions

Shared Mobility has been proven by previous research to have a number of environmental benefits – as for the reduction of emissions of pollutants – and to reduce the number of vehicles on the streets by reducing private ownership of cars. The evidence shown in this work through literature review and cases of implementation in European cities indicate that Shared Mobility can play a role as a multimodal solution for urban mobility, either by physically integrating it to public transport and other modes through station integration, and/or digitally integrating it through a MaaS platform, which can offer integration at the levels of information, routing, booking and payment.

The integration, either physical or digital, of Shared Mobility as a multimodal option for urban mobility makes it easier for users to use shared modes around public transport, and hence makes it easier for them to take the decision of leaving their cars and shift from the mobility ownership paradigm.

As MaaS and Shared Mobility are relatively new concepts, there are still many challenges to overcome. Some of the challenging issues identified in this work are the funding problem, physical space availability for physical integrations, suitability of public transport development for MaaS systems, partnerships and collaboration between stakeholders, cultural mobility paradigms in societies, further integration of other shared modes not yet integrated in this kind of system (as ride-sharing and ride-sourcing), and the integration of shared modes to other high traffic urban points. It remains as a task for the academic world and practitioners to keep exploring these challenges and propose alternative solutions to make urban mobility more and more sustainable.

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