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RAPHAËL PHILIPPE LIONEL MARIE ALAIN GRAS

MOBILITY-AS-A-SERVICE PLATFORM: A STUDY OF URBAN MOBILITY IN SÃO PAULO

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Committee members:

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Profa. Susana C. Farias Pereira (Advisor)

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Prof. Renato J. Orsato

____
Prof. Minelle E. Silva

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ABSTRACT

The concept of Mobility-as-a-Service (MaaS) recently emerged with the rise of new mobility solutions and the increasing need for multimodality in cities. The existing literature on MaaS schemes focuses on cities in developed economies, and the concept has yet to be applied to emerging countries. São Paulo possesses a massive and congested urban mobility system generating negative economic, social and environmental externalities. Hence, MaaS represents a strong opportunity to respond to the challenges of urban mobility in the city. This case study provides mobility stakeholders with a vision of the potential characteristics of an actionable MaaS platform for the city of São Paulo by drawing a detailed description of the urban mobility system and exposing options for the potential characteristics of a MaaS scheme.

Keywords: Mobility-as-a-Service, urban mobility, integrated mobility, transportation, innovation, innovative mobility services, São Paulo

RESUMO

O conceito de Mobility-as-a-Service (MaaS) nasceu recentemente com a criação de novas soluções de mobilidade e a necessidade crescente de multimodalidade nas cidades. A literatura existente sobre esquemas de MaaS está focada em cidades em países desenvolvidos, e o conceito ainda tem que ser aplicado aos países em desenvolvimento. A cidade de São Paulo possui um dos sistemas de mobilidade urbana mais massivos e congestionados dos países em desenvolvimento, gerando externalidades econômicas, sociais e ambientais negativas na megapole. Então, MaaS representa uma grande oportunidade de responder aos desafios da mobilidade urbana na cidade. Esse estudo de caso proporciona aos atores da mobilidade uma visão das características potenciais de uma plataforma de MaaS acionável na cidade de São Paulo fazendo uma descrição detalhada do sistema de mobilidade urbana e expondo opções para as características potenciais de uma esquema de MaaS.

Palavras chaves: Mobility-as-a-Service, mobilidade urbana, mobilidade integrada, transporte, inovação, serviços inovadores de mobilidade, São Paulo

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1. Introduction

On average, Paulistanos spend 2 hours commuting to their main activity each day (Rede Nossa São Paulo, 2017). This time is 56 minutes in China, 49 minutes in Mexico, 44 minutes in India, 25 minutes in the U.S.A. and as low as 21 minutes in Sweden (Statista, 2016). São Paulo dramatically lacks mass transportation infrastructure. The city only has 5 km of metro line for 1 million inhabitants. In the meantime, other Latin American megalopolis have higher standards: Mexico City got 10 km of line for each million inhabitants (Ribeiro de Carvalho, 2016). As a result, the urban road network is frequently over-utilized since most Paulistanos hardly have any better option than individual vehicles to commute. According to INRIX (2018), São Paulo is the 4^{th} most congested city in the world, behind Los Angeles, Moscow and New York City. The average driver in São Paulo spends 86 hours per year caught in traffic congestion. São Paulo's roads are congested 22% of the time and only four major cities (Bogota, Moscow, Bangkok and Caracas) are congested more often.

The negative externalities of traffic congestion are countless. The most straightforward is the productivity loss for citizens. Time spent in traffic congestion is unproductive for commuters and constraints economic actors to adapt to longer itineraries, impeding them to act in the most productive way (Sweet, 2011). In Brazil, the estimated economic loss due to traffic congestion is 1.8% of GDP (Szczerbacki Besserman Vianna & Frickmann Young, 2015) – the equivalent of R$ 1,171 billion only for the municipality of São Paulo (Sistema Estadual de Análise de Dados [SEADE], 2015). Second, long commuting time is an aggravating factor of social inequalities, since the poorest populations are most likely living in the peripheries, far from the economic centers, and to have little access to public transportation facilities (Pero & Mihessen, 2013). Traffic

congestion generates air pollution and consequently has negative effects on public health, causing respiratory diseases, morbidity and premature mortality to both commuters and citizens (Zhang & Batterman, 2013), and evidently on the environment. Other negative externalities like quality of living linked with noise and stress, schedule flexibility or illegal collective transportation (*vans* in Brazil) can also be mentioned.

The current urban mobility situation is a plague for São Paulo. A survey held by Rede Nossa São Paulo and Ibope (2017) shows high levels of dissatisfaction of Paulistanos about mobility. No aspects regarding mobility evaluated in the survey reaches average satisfaction levels in the survey; public transportation (3.8/10), commuting time (3.4/10) and time lost in traffic (2.7) are among the most concerning figures. Trends do not forecast a brighter future in the short run. Even if it is losing momentum, the urbanization process is continuing: in 2030, 90% of the Brazilian population is expected to be urban (ONU-Habitat, 2016). São Paulo should receive its fair share of the phenomenon and see its population increase accordingly. Besides, the automotive market is back to growth with double digits rates with a forecast of +11.9% of sales in 2018 after an increase of 8.6% in 2017 (Federação Nacional da Distribuição de Veículos Automotores [FENABRAVE], 2017). Moreover, annual infrastructure efficiency losses are equivalent to yearly new investments in infrastructure. As a result, the quality of the Brazilian infrastructure is stagnating, and the upcoming utilization increase due to new vehicles may even deteriorate existent facilities (World Bank, 2017). Hence, to be expected: more traffic congestions along with the negative externalities cited above and increasing commuting times for Paulistanos.

Nevertheless, opportunities exist to reverse the trend of degradation of mobility conditions in São Paulo. Recent technological and business-model disruptions provided urbanites with a wide range

of transportation modes for their daily mobility needs. Benevolo, Dameri, and D'Auria (2016) listed the options available to commuters in *Smart Cities* on top of traditional public transit systems: car-sharing, car-pooling, bike-sharing, ride-sharing, electric vehicles, autonomous vehicles São Paulo already possesses many of these new mobility solutions: car-sharing (Época Negócios, 2017), ride-hailing (Uber, 2018), bike-sharing (PBSC, 2018), car-pooling (BlaBlaCar, 2018).

Because of the proliferation of new mobility solutions in addition to the traditional public transit networks, passengers worldwide have various modal options to accomplish the same trip (multimodality*)* and can even combine several modes in the same trip (inter-modality*)* (Willing Brandt & Neumann, 2017). Yet, commuters encounter several pain-points when it comes to combining more than 2 modes for the same trip (Kamargianni & Matyas, 2017). First, journey planning apps may not include all available options in a given area, especially new solutions. Only few design intermodal itineraries, in particular across public transportation and private solutions (ex: ride-hailing, carpooling). Then, ticketing across modes is rarely unified – except for public transportation – so commuters must get different tickets when changing modes. Eventually, payment methods can differ from one mode to another (cash in taxis, credit card in ride-hailing).

To overcome these pain-points, a new concept called Mobility-as-a-Service (MaaS) emerged. König, Eckhardt, Aapaoja, Sochor and Karlsson (2016) provide the latest and most comprehensive definition of MaaS: *"Multimodal and sustainable mobility service addressing customers' transport needs by integrating planning and payment on a one-stop-shop principle"*. From a user's perspective, MaaS is a single interface on which the client plans an intermodal journey, pays and gets tickets for all the modes they are going to use, and follows the progression of the trip in real-

time (Jittrapirom, Caiati, Feneri, Ebrahimigharehbaghi, Alonso-González, & Narayan, 2017). Such platforms have the potential to improve time and cost efficiency of mobility for users (Willing et al., 2017) and to distribute more evenly the demand according to the available capacities of each transport operator (Kamargianni & Matyas, 2017). Therefore, developing a MaaS platform in São Paulo represents an interesting opportunity to improve mobility conditions in the city.

1.1. Research question and objectives

Even if the concept of Mobility-as-a-Service (MaaS) is very recent, the existing literature on the topic provides rich insights. Several studies attempted to define the concept (Hietanen, 2014; Atkins, 2015; König et al., 2016) and highlight the main characteristics of MaaS platforms (Jittrapirom et al., 2017). Other researches (Holmberg, Collado, Sarasini, & Williander, 2016; Kamargianni & Matyas, 2017) set the scope of the MaaS provider business ecosystem by identifying its main actors and stakeholders with their respective roles. Previous studies (Holmberg et al., 2016, Jittrapirom et al., 2017, König et al, 2016) benchmarked the past and current MaaS schemes in Europe and North America and described the main characteristics and ecosystem of each platform. Eventually, Kamargianni et al. (2015) performed a feasibility study for a MaaS platform in London. Therefore, the existing literature on MaaS schemes is exclusively focused on cities in developed economies. The application of the MaaS concept in metropolises of emerging countries – especially in Latin America and Brazil – has yet to be discussed by researchers. Hence, the main research question of this paper arises:

- What Mobility-as-a-Service platform design would best fit São Paulo's urban mobility system?

The main objective of this study is to provide mobility stakeholders (transport providers, authorities and users among others), both in Brazil and abroad, with a proposition of the potential characteristics of an actionable MaaS platform for the city of São Paulo. The secondary objective is to identify the main players to be considered in the development of a MaaS project in São Paulo and to define the role they could potentially play in such a scheme. Additional objectives are to identify the main tools on which the MaaS scheme can build on and to evaluate the potential benefits for the users.

This paper first presents a review of the literature on urban mobility and MaaS (section 2.). Then section 3. sets the scope of the study and explains the methodology employed. Section 4. contextualizes the study with a deep description of the urban mobility system of São Paulo. Section 5 presents the main findings of the study that are interpreted and discussed in the following section (section 6.). Eventually, section 7. concludes the paper.

2. Literature Review

In this section, we will provide a review of past studies on urban mobility, including definition and scope, main theoretical concepts and recent evolution. Then, we will introduce the concept of Mobility-as-a-Service (MaaS) by presenting the attempts of definition in the literature and main characteristics. We will also detail the main players of the MaaS ecosystem and conclude by identifying the main implementation challenges present in the literature.

According to Rodrigue (2017), urban mobility describes the movements of passengers and freight between points of the same urban area. Urban mobility is enabled by various modes like walking, biking, road, rail or boat. and supported by transportation infrastructure. This study will be focused on passenger mobility. This type of movements are the results of individual choices and follow

four patterns: pendulum movements, professional movements, personal movements and touristic movements. Rodrigue (2017) develops that the intensity of the mobility needs depends on trip generation (number of trips per passengers), modal split (modes available to accomplish a give trip), routing (itinerary chosen to link two destinations) and destination (spatial distribution of activities in the urban area).

Inside each city, urban mobility is organized as a system. McKinsey & Company (2015) provides a framework to understand how urban mobility systems work. First, urban mobility systems rely on the city baseline characteristics: density of population, transport infrastructure, quality of public transit, physical distribution of activities. The city baseline enables a wide set of actors to deliver mobility, or put differently, to take passengers from one point of the urban area to another. These actors are motorized individual vehicles (mainly cars and motorbikes), walking, biking, public transit with various modes (for example rail, bus and ferries) and new mobility services (such as car sharing and ride-hailing). Three factors shape the system and influence the way these actors deliver mobility: policies and regulations, land use and urban planning, and consumers preferences and behaviors. Eventually, three enablers give the possibility to mobility deliverers to provide their services: technology, financing and new business models.

In the last ten years, the rise of new information and communication technologies (ICT) started a revolution of urban mobility systems, with three major evolutions. First, Cohen-Blankshtain and Rotem-Mindali (2013) bring evidence that new activities such as tele-working, tele-leisure and e-commerce reduced travel demand (especially for professional and personal movements), yet, the increased real-time information users get thanks to mobile ICT provides them with increased flexibility in route planning and tends to generate more trips. They conclude that ICT do not only

reduce or increase travel demand, but they change traditional urban mobility patterns. The second main is the development of Intelligent Transportation Systems (ITS). ITS are the result of the use of technologies, both on infrastructures and vehicles, to improve the efficiency of an urban mobility system by optimizing available capacities to better meet passengers demand (Cohen-Blankshtain & Rotem-Mindali, 2013). The last main evolution is the creation of new shared mobility services powered by business model innovations enabled by technological breakthroughs. Cohen and Kietzmann (2014) state than even if shared mobility business models existed before the rise of new ICT, technologies such as mobile GPS localization were crucial enablers to scale services like car-sharing or bike-sharing, whereas new solutions like ride-hailing (ex: Uber, 99 Taxi) are heavily relying on real-time mobile internet connection.

The rise of new ICT over the last two decades gave passengers a wide range of new mobility options (Deloitte, 2017). The latest evolution of urban mobility tends towards intermodal systems where passengers combine 2 or more transport modes to accomplish a single journey (Müller, Riley, Asperges, & Puig-Pey, 2004). Willing et al. (2017) listed the main benefits of intermodal trips: offering tailored for user's needs, time and cost efficiency, increasing competition among transport modes dragging mobility prices down, and substitution of individual vehicle for more environment-friendly modes. Deloitte (2017) pin that journey planning apps have become mainstream to help users compare among their options and design intermodal trips, yet they do not fully integrate them in an end-to-end solution.

The concept of Mobility-as-a-Service (MaaS) emerged from this need for integration of mobility options and inter-modality. The first comprehensive definition of MaaS was provided by Hietanen (2014, p. 2) as follow: *"A mobility distribution model in which a customer's major transportation*

needs are met over one interface and are offered by a service provider. [...] The central element of Mobility-as-a-Service requires a mobility platform that offers mobility services across modes”. Starting from this basis, following studies tried to precise this definition. Atkins (2015, p. 19) highlight in their definition the user-centric nature of MaaS solutions: *“The provision of transport as a flexible, personalised on-demand service that integrates all types of mobility opportunities and presents them to the user in a completely integrated manner to enable them to get from A to B as easily as possible”*. König et al. (2016, p. 10) emphasize three main dimensions of MaaS, shared mobility, booking/ticketing and multimodal traveller information: *“Multimodal and sustainable mobility services addressing customers' transport needs by integrating planning and payment on a one-stop-shop principle”*.

It is important to remark that MaaS services are not shared mobility services. Botsman and Rogers (2010) observed three main characteristics of the sharing economy: product services systems, redistribution markets and collaborative lifestyles. MaaS services do not include at the last two features. Martin (2016) identified two types of innovations related to the sharing economy extremely relevant for mobility: car and ride sharing platforms and peer-to-peer platforms for sharing assets. MaaS schemes are likely to employ such shared service to reach its goals but is not a shared service itself. Hence, it is more appropriate to see MaaS companies as aggregators of transport modes including shared mobility services rather than a shared mobility service itself.

In an extensive literature review, Jittrapirom et al. (2017) identified nine core characteristics of MaaS solutions, as in table 1.

Table 1: Description of MaaS' core characteristics based on literature review.

Core Characteristic		Description
(1)	Integration of transport modes	A goal of MaaS schemes is to encourage the use of public transport services, by bringing together multi-modal transportation & allowing the users to choose and facilitating them in their intermodal trips. Following transport modes may be included: public transport, taxi, car-sharing, ride-sharing, bike-sharing, car-rental, on-demand bus services. […]
(2)	Tariff option	MaaS platform offers users two types of tariffs in accessing its mobility services: "mobility package" and "pay-as-you-go". The package offers bundles of various transport modes and includes a certain amount of km/minutes/points that can be utilized in exchange for a monthly payment. The pay-as-you-go charges users according to the effective use of the service.
(3)	One platform	MaaS relies on a digital platform (mobile app or web page) through which the end-users can access to all the necessary services for their trips: trip planning, booking, ticketing, payment, and real-time information. Users might also access to other useful services, such as synchronization with personal activity calendar, travel history report, invoicing, and feedback.
(4)	Multiple actors	MaaS ecosystem is built on interactions between different groups of actors through a digital platform: demanders of mobility (e.g. private customer or business customer), a supplier of transport services (e.g. public or private) and platform owners (e.g. third party, PT provider, authority). Other actors can also cooperate to enable the functioning of the service and improve its efficiency: local authorities, payment clearing, telecommunication and data management companies.
(5)	Use of technologies	Different technologies are combined to enable MaaS: devices, such as mobile computers and smartphones; a reliable mobile internet network; GPS; e-ticketing and e-payment system; database management system and integrated infrastructure of technologies (i.e. IoT).
(6)	Demand orientation	MaaS is a user-centric paradigm. It seeks to offer a transport solution that is best from customer's perspective to be made via multimodal trip planning feature and inclusion of demand-responsive services, such as taxi.
(7)	Registration requirement	The end-user is required to join the platform to access available services. An account can be valid for a single individual or, in certain cases, an entire household. The subscription not only facilitates the use of the services but also enables the service personalisation.
(8)	Personalisation	Personalisation ensures end users' requirements and expectations are met more effectively and efficiently by considering the uniqueness of each customer. The system provides the end-user with specific recommendations and tailor-made solutions on the basis of her/his profile, expressed preferences, and past behaviors (e.g. travel history). Additionally, they may connect their social network profiles with their MaaS account.
(9)	Customisation	Customisation enables end users to modify the offered service option in according to their preferences. This can increase MaaS' attractiveness among travelers and its customers' satisfaction and loyalty. They may freely compose a specified chained trip or build their mobility package with a different volume of usage of certain transport modes to better achieve their preferred travel experiences.

Source: Jittrapirom et al. (2017)

Each of these categories has been further discussed in the literature. Holmberg et al. (2016) identified that MaaS schemes must integrate several transportation modes (1), including public

transit and shared mobility services. Three main tariff options (2) are available to MaaS users: *pay-as-you-go* or *mobility package* that offers bundles of minutes or kilometers of mobility against a monthly payment, or a combination of both, as explained by Matyas and Kamargianni (2017). König, Piri, Karlsson, Sochor and Heino (2017) show that MaaS rely on a unique digital platform (3) which can be either a mobile app or a website for their core features (trip planning, booking, ticketing, payment, and real-time information) and is supported by technologies (5) such as mobile, internet, GPS, e-payment, and data management systems. The MaaS ecosystem involves various actors (4), primarily users (individuals or business customers), suppliers of transport services (public or private) and platform owners (third party, public transport providers, authorities) as identified by Spickermann, Grienitz and Von der Gracht (2014) and their collaboration is key to the success of the platform (Ambrosino, Nelson, Boeroc & Ginia, 2015). Mirri, Prandi, Salomoni, Callegati, Melis and Prandini (2016) developed that these services are demand-oriented (6) and try to optimize the user's mobility experience rather the suppliers' interests. Civitas' study (2016) pins that the platform requires to create an account (7) and sign in prior to use. The registration enables personalization (8) and customization (9) of transport modes to fit best the user's preferences as explained by Melis, Mirri, Prandi, Salomoni, Callegati and Prandini (2016).

Since MaaS platforms are user-centric (Atkins, 2015), the main stakeholder in the ecosystem is the end-user. Sochor, Ströberg and Karlsson (2014) deduced the main motivations for adoption out of a survey of users of UbiGo, a Swedish MaaS service. They demonstrate that curiosity moves the early adopters, yet convenience and economic advantage compared to other mobility means motivate further use of the service. In a following study based on the same surveyed sample, Sochor, Ströberg and Karlsson (2015) showed a holistic approach of mobility could change travel

behaviors. Most UbiGo users shifted towards more multimodal and sustainable mobility solutions, with scarcer use of individual vehicles and to the profit of sharing mobility solutions and public transportation.

Kamargianni and Matyas (2017) identified the other players of the MaaS business ecosystem. Apart from the users, the core business partners of the MaaS provider are transport operators, that perform mobility services and give access to their API for data collection, and data providers that aggregate the data from the transport operators and other sources to make it useable by the MaaS provider. Players in the extended enterprise of the MaaS provider include technical back-end providers (IT infrastructure), payment and ticketing solutions, multimodal journey planners and insurance companies. Eventually, regulators and policy makers, investors, research institutes, unions, and media and marketing firms are broader stakeholders of the MaaS provider ecosystem.

The numerous technological actors in the MaaS ecosystem reveal that IT infrastructure is a prerequisite for cities to be support effective MaaS providers. Finger, Bert and Kupfer (2015) assume the technological tools to enable MaaS already exist, but the main challenge lies in the availability and quality of each actor's technological infrastructure to provide reliable data to the aggregator. Nemtanu, Schlingensiepen, Buretea and Iordache (2016) consider MaaS services as a component of smart cities since they enable smart mobility and rely on information exchanges between individual vehicles, public transportation, taxis, car sharing, bikes, pedestrians, shops and other services. To be able to exchange this information efficiently, each of theses actors must have sensors and the data they generate must be uniformized through open and interoperable Application Programming Interfaces (API) (Kamargianni & Matyas, 2017). The challenge is to

create new APIs standards to integrate route planning, real-time vehicle localization, ticketing and billing in a safe manner.

Despite these technological challenges, MaaS platform are being developed in increasing numbers in developed countries. König et al. (2016) made an inventory of past and existing MaaS platforms of all scale. They counted 23 projects as of 2016 in 8 countries, exclusively in Europe and North America. In the same study, they also counted 14 advanced R&D projects related to MaaS, in Finland and Sweden mainly. Jittrapirom et al. (2017) made a detailed comparison of 13 MaaS projects in Europe, North America and Australia based on 9 main core characteristics (presented earlier), revealing different degrees of integration of transport modes and features among the past and existing schemes. Kamargianni et al. (2016) attempted to quantify the degree of integration of transport modes and features of the MaaS platforms. They built the MaaS integration index, which variables are the number of modes available on the platform, the presence of ticketing and payment features for each mode, journey planning tool, booking system and mobility package option. This index enabled them to rank 15 MaaS providers in Europe and the U.S. according to their degree of integration.

Eventually, to the best of our knowledge, the literature on MaaS only counts one public feasibility study, led by Kamargianni et al. (2015) for the city of London. The first objective of the study is to provide a potential design for the MaaS platform in London based on previous MaaS projects in Europe, potential stakeholder in London's urban mobility system and travel pattern of Londoners. Then, the researchers evaluated the operational, technical and economic feasibility of the previously defined MaaS scheme.

3. Scope and methodological approach

3.1. Type of methodology

This study is a qualitative research. Hence, it presents the core characteristics of qualitative studies presented by Creswell (2014). In particular, it will have a natural setting, meaning that data will be collected directly from the field, and multiple sources including interviews and documentary research. The specific design of this qualitative research is a case study. At the light of Yin's definition (2009, p. 18), the research will "*investigate a contemporary phenomenon* (here, Mobility-as-a-Service) *in depth within its real-life context* (in our case São Paulo's urban mobility system) *especially when the boundaries between phenomenon and context are not clearly evident* (MaaS being an emerging concept with no actual application in São Paulo at the time this research is performed).

3.2. Scope

The research focuses on the urban mobility system of the municipality of São Paulo. With a population of 12.1 million inhabitants, it represents 57% of the population of the metropolitan region of São Paulo. In addition, the municipality of São Paulo provides more than 60% of the GDP of the metropolitan region (Empresa Paulista de Planejamento Metropolitano SA [EMPLASA], 2018). Every day, 26.5 million trips are taken in the municipality of São Paulo, accounting for 60% of the total of trips taken in the metropolitan region (Companhia do Metropolitano de São Paulo [CMSP], 2013). This data shows that the municipality of São Paulo is demographically and economically the most dominant sub-region in the metropolitan area, and the most dynamic one for urban mobility.

In addition of being the center of its metropolitan area, São Paulo is an important city for urban mobility at the national and global scale. São Paulo is the largest city in Brazil and in Latin America: it is twice as populated as Rio de Janeiro and has 4 million more inhabitants than Mexico City (World Atlas, 2018). Overall, São Paulo is the twelfth most populated city in the world (World Atlas, 2018). The number of trips taken in São Paulo is also the largest in the country and the continent: Rio de Janeiro only has 11.7 million daily trips (Governo do Estado do Rio de Janeiro – Secretaria de Estado de Transportes [SETERJ], 2017) – 44% of São Paulo's total – and Mexico City 20.6 million trips (Fideicomiso para el Mejoramiento de las Vías de Comunicación del Distrito Federal [FIMEVIC], 2018) – 78% of São Paulo's figure.

The selection of stakeholder to be interviewed on the supply side of the MaaS ecosystem (König et al., 2016) focuses on core business partners of the MaaS providers (Kamargianni et al. 2017). Operating in the municipality of São Paulo was the first selection criteria for interviewees. Considering the objective of providing a vision of the main characteristics MaaS could have in São Paulo rather than building an implementation plan for such a service, core business partners that do not influence the characteristics of the MaaS scheme (Jittrapirom et al., 2017) like third party data providers and technology suppliers were not considered as potential interviewees. The stakeholders of the MaaS business ecosystem that do not belong to the core business partners were also excluded for the same concern. Table 2 provides an overview of the interviewees of this study.

Table 2: Interviewees' overview

Sector	Organization	Role	Interviewee	Date	Duration
Public administration & public transportation	Public administration mobility & transports	Planning and management advisor	GOV_1	25.06.2018	1:02:17
	Public administration innovation	Innovation coordinator	GOV_2	27.06.2018	27:34
	Public-private partnerships company	Direction accessory	GOV_3	29.06.2018	41:51
Ride-hailing	Major ride hailing company	Global consultant	RIDE_HAIL	19.06.2018	46:40
Bike-sharing	Electric bike renting company	CEO	BIKE_SHARE_1	27.06.2018	29:02
	Bike sharing system operator	Project and implementation manager	BIKE_SHARE_2	08.08.2018	41:38
	Bike sharing system operator	Relationship coordinator	BIKE_SHARE_3	08.08.2018	41:38
Innovation	Major business administration university	Professor, innovation and design thinking specialist	INNOV_1	19.06.2018	38:18
	Mobility innovation laboratory	Co-founder	INNOV_2	26.06.2018	42:33
Mobility services	Mobility payment app	CEO	MOB_SERVICE_1	28.06.2018	32:01
	Data analysis software company	CEO	MOB_SERVICE_2	02.07.2018	37:32
	Corporate mobility company	CEO	MOB_SERVICE_3	30.07.2018	28:24

Source: Author

The demand side of the MaaS ecosystem (König et al., 2016) that enters the scope of this study are the users of the urban mobility system inside the boundaries of the municipality of São Paulo. This may include inhabitants of the municipality during their daily commuting inside the limits of the municipality, inhabitants of surrounding municipalities commuting inside the municipality boundaries (hence commuting in and out of the municipality is excluded) and visitors in the municipality.

3.3. Data collection strategy

In line with Creswell's characteristics of a qualitative research (2014), this paper relies on several sources to collect data, including documents and face-to-face interviews. Public documents such as academical studies, industry reports, governmental reports and newspaper articles were reviewed and analyzed.

Qualitative face-to-face or telephone interviews were performed with the relevant stakeholders of the supply side of the MaaS provider (cf. Scope). These interviews were semi-structured since they rely on an interview protocol (appendix 1) prepared previously (Creswell, 2014) and built around the nine core categories of MaaS scheme presented by Jittrapirom et al. (2017). The objective of the interview protocol is to provide reliability to the data collected during the interviews. The interviews were made preferably in English to avoid translation biases, but some of them were conducted in Portuguese at request of the interviewee. The interviews were audiotaped, and their content transcribed to enable subsequent analyses.

To ensure the highest representativeness of the data on the demand side, the data collection strategy selected was analysis of secondary data. Indeed, the large number of users of the urban mobility system requires large scale studies in order to collect quantitative and qualitative data on mobility patterns and preferences. The sources used for this purpose were mobility surveys, industry reports and demographic surveys. The main documents studied are presented in table 3.

Table 3: Sources of secondary data

Year	Author(s)	Title	Type of document
2018	ADETAX	Estatísticas	Database
2017	Clewlow, R. and Gouri, S.M.	*Disruptive Transportation: the adoption, utilization, & impacts of ride-hailing in the U.S.*	Academic research
2017	Confederação Nacional do Transporte (CNT)	*Pesquisa CNT de rodovias 2017 – Relatório gerencial*	Industry report (roads)
2017	Rede Nossa São Paulo, Cidade dos Sonhos & Ibope Inteligência	*Pesquisa de Mobilidade Urbana*	Mobility survey
2013	Companhia do Metropolitano de São Paulo	*Pesquisa de mobilidade da região metropolitana de São Paulo 2012 – Síntese das informações – Pesquisa domiciliar*	Mobility survey

Source: author

The secondary data collected with this strategy was reinforced by the inputs from the qualitative interviews of mobility stakeholders (Creswell, 2014), especially on their perception of the market, the major trends in mobility and past experience in the industry.

3.4. Data analysis procedure

Data analysis in this research followed the five-step process presented by Creswell (2014). First, the audiotapes from the interviews were transcribed to enable coding. Then, transcribed interviews were coded using a specialized software for coding large amounts of qualitative data (nVivo). Out of the coding process, categories of qualitative data were deduced (4 core categories, 13 secondary categories and 37 tertiary sub-categories) to provide the set of characteristics of a MaaS service in São Paulo (cf. Table 4). The next step was data representation, which consisted first in a description of the urban mobility system in the municipality of São Paulo and second an analysis the core characteristics of a MaaS service proposed for São Paulo. Note that the coding process was made in the original language of the interview (English or Portuguese) and the selected quotes were later translated before being presented in the final report. Eventually, the interpretation of the data

includes a comparison of the MaaS vision for São Paulo with other MaaS schemes characterization attempts in the literature and questions the comparability of MaaS schemes in developed countries and in Brazil and developing countries.

Table 4: Categories of qualitative data analysis

Core categories	Secondary categories	Tertiary sub-categories
Demand orientation	**Customer service**	Contact channels
		Help content
		User-generated content
	Personalization	Premium membership
		Additional features
		Automated personalization
	Benefits	Time economy
		Increased satisfaction
		Health & well-being
Multiple actors	**Transport providers**	Public transportation
		Ride hailing
		Biking & bike-sharing
	Inter-modality	Networks integrations
		Physical integration (infrastructure)
		Data sharing and integration
	Coordinator	Private coordinator
		Public coordinator
		Public & private cooperation
	Regulation	State & City responsibilities
		Standards & goals
Technologies	**Journey planning**	Open data
		IT infrastructure and software
		Service providers
	Platform	Mobile app
		Basic features
		Registration
	Ticket validation	Mobile validation
		Electronic tickets
		Validation hardware
Payment	**Intermodal payment**	Electronic ticketing system
		Distribution of revenues
	Means of payment	Credit & debit cards
		Cash
		Invoicing
	Tariff options	Pay-as-you-go
		Pre-paid subscription
		Free initiatives

Source: author

3.5. Data validation

Three strategies were implemented to ensure the validity of the collected data, according to Creswell's data validation strategies (2014). First, the categories extracted from the qualitative interviews triangulated with findings from the literature review. Second, the final report (full or parts) was submitted to participants of the study for a member checking. The objective of the member checking was to collect feedback on the accuracy of the findings and may require follow-up interviews. The third strategy used to validate the data was peer debriefing, in particular by researchers of FGV from the operations management, entrepreneurship and public administration departments.

4. Contextualization: urban mobility system in the municipality of São Paulo

The objective of this section is to deeply present the environment on which the study is set to give a better understanding of the potential characteristics of a MaaS platform in São Paulo presented in section 5.2. This section provides an overview of the urban mobility system in the municipality of São Paulo. It is divided in two subsections built on the offer and demand model in a matter of exhaustiveness: section 4.1. first explores the travel patterns of passengers (demand) and section 4.2. then presents the urban transportation providers available in the city of São Paulo (offer).

4.1. Passenger travel patterns in the municipality of São Paulo

Section 4.1. aims at drawing a picture of the travel patterns of Paulistanos in urban mobility. To do so, it first studies the trips taken by the citizen, especially the number of trips, their duration and the modes used to accomplish them. Then, it focuses on inter-modality in São Paulo with the number of transfers and the modes implied in transfers.

4.1.1. Characteristics of urban trips

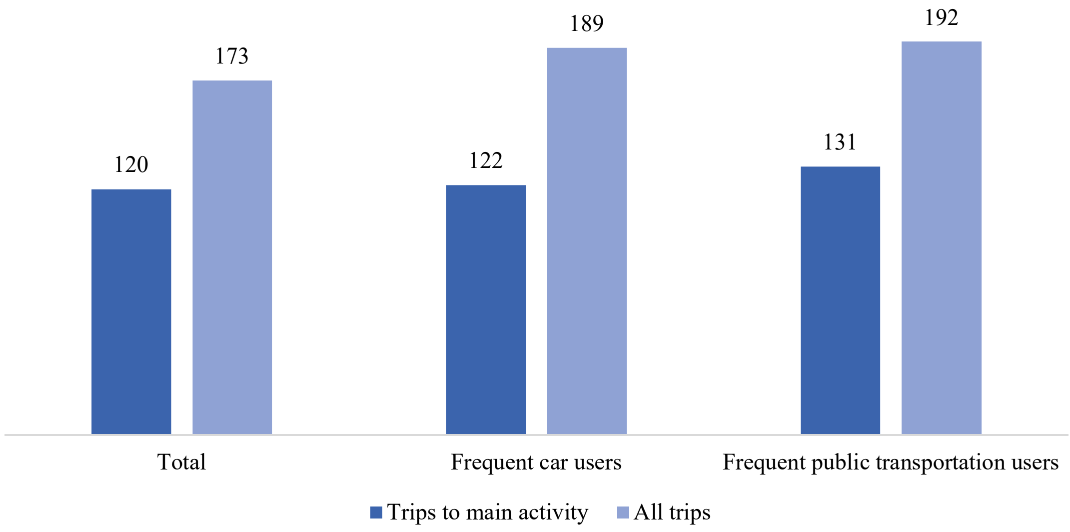
4.1.1.1. Number of trips and mobility index

According to the Company of São Paulo's Metropolitan (Companhia do Metropolitano de São Paulo [CMSP], 2013), 26.6 million daily trips were taken in the municipality of São Paulo in 2012. Compared to the previous similar study in 2007, this number increased by 11.3% while the city's population only grew by 4.4%. The mobility index (number of daily trips per inhabitant) hence reached 2.33 in 2012, growing by 8.4% from 2.15 in 2007. Most of these trips are internal to the city, meaning that the starting and ending point of the trips are both localized inside the boundaries of the city: in 2012, 88% of motorized trips were internal to the municipality of São Paulo.

4.1.1.2. Trip duration

According to a survey published in 2017 by Rede Nossa São Paulo, Cidade dos Sonhos and Ibope, the average commuting time to the main activity for Paulistanos was 2h00 in 2017 (Rede Nossa São Paulo, 2017). This duration increased by 16 minutes compared to 2015. People using their cars every day or almost everyday spend on average 2h02 hours commuting to their main activity, against 2h11 for people travelling by public transportation everyday or almost every day. When considering all the trips taken in a day (trips to main activity and other trips such as shopping entertainment or getting children to/from school), Paulistanos spend 2h53 in transit each day, including 3h09 for frequent car users and 3h12 for regular public transportation users. Figure 1 show an overview of the commuting durations in São Paulo.

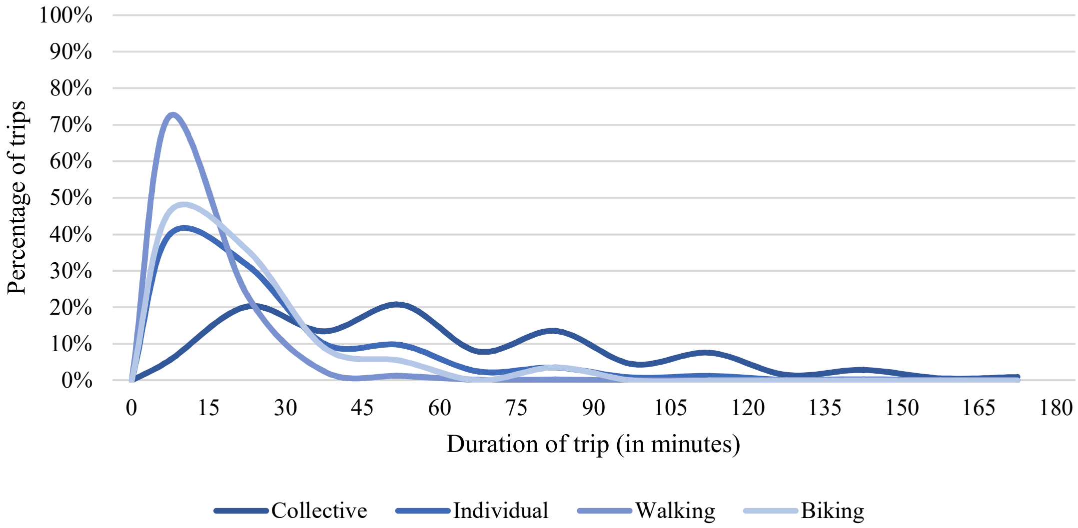
Figure 1: Average time spent commuting daily by an inhabitant of São Paulo (in minutes)



Source: based on Rede Nossa São Paulo (September 2017)

At the trip level, the differences among transport modes are more important when it comes to duration of the trip. As shown in figure 2 (CMSP, 2013), there is an important difference in average trip duration between individual and collective transportation in São Paulo. The clear majority of commuters using individual transport modes spend less than 30 minutes to accomplish a trip. When the transport mode is also non-motorized (walking and biking), almost all trips last 30 minutes or less. On the contrary, Paulistanos commuting by collective transport modes are likely to spend 45 minutes or more to finish a trip.

Figure 2: Distribution of trips per duration and mode in São Paulo

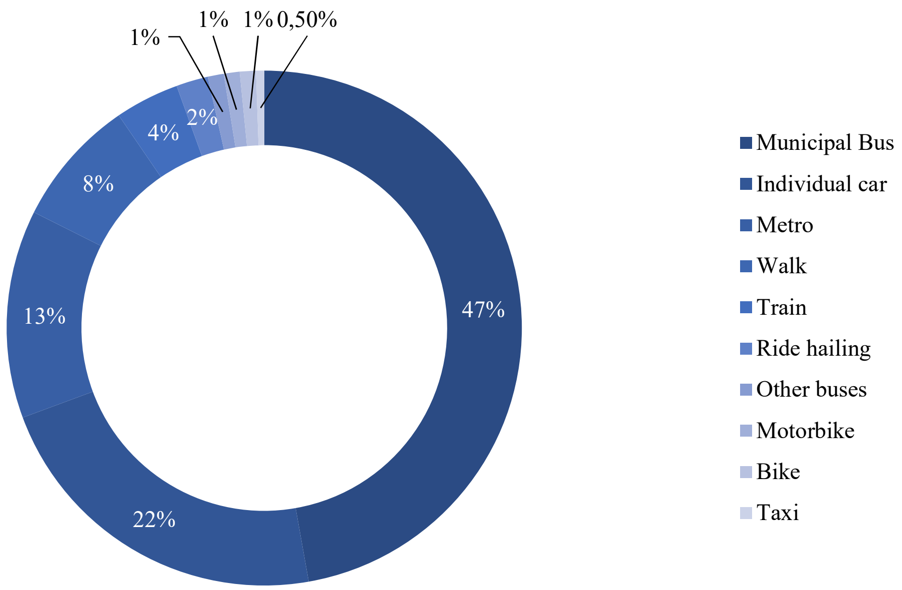


Source: based on CMSP (December 2013)

4.1.1.3. Modal breakdown

According to Rede Nossa São Paulo (2017), almost half of Paulistanos declare that buses is their primary mode of commuting in the city. Around a quarter of them use their private cars to move around and the city, 17% commute by rail and the remaining walk, bike, hail rides or taxis or ride a bike. Figure 3 show the breakdown of transportation modes used as primary transport mode by inhabitants of São Paulo.

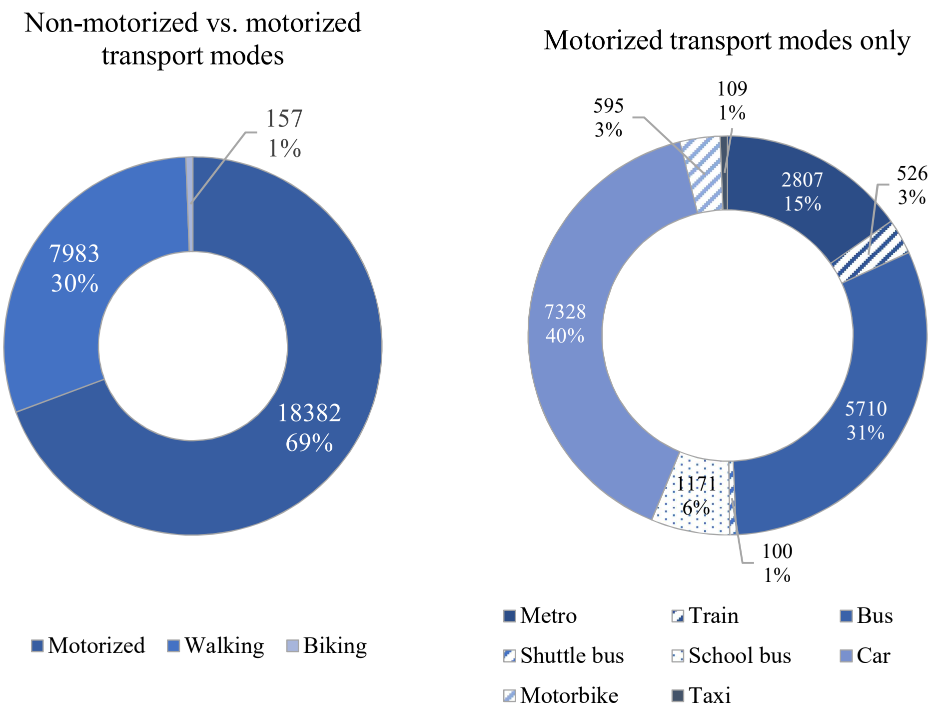
Figure 3: Transportation mode most frequently used by Paulistanos



Source: based on RNSP (September 2017)

According to the CMSP (2013), motorized transport modes are largely predominant in São Paulo. As shown on figure 4, walking and biking account for 31% of daily trips against 69% for the motorized trips. Inside the group of motorized transport modes, individual transport modes account for 43% of trips, including car with 40% and motorbike for 3%. Consequently, collective transportation remains the most used transport mode with the remaining 57% of trips. Among collective transport modes, buses account for the majority of trips since traditional buses represent 31% of trips, school buses 6% and shuttle buses 1%. Rail, with 18% of trips is a minor transport mode in the metropolis. The metro handles 15% of trip and train 3%. Taxis and other motorized transport modes complete the panorama with respectively 109,000 and 31,000 daily trips, less than 1% of the city's total.

Figure 4: Daily trips per transport mode in the São Paulo (in thousands)



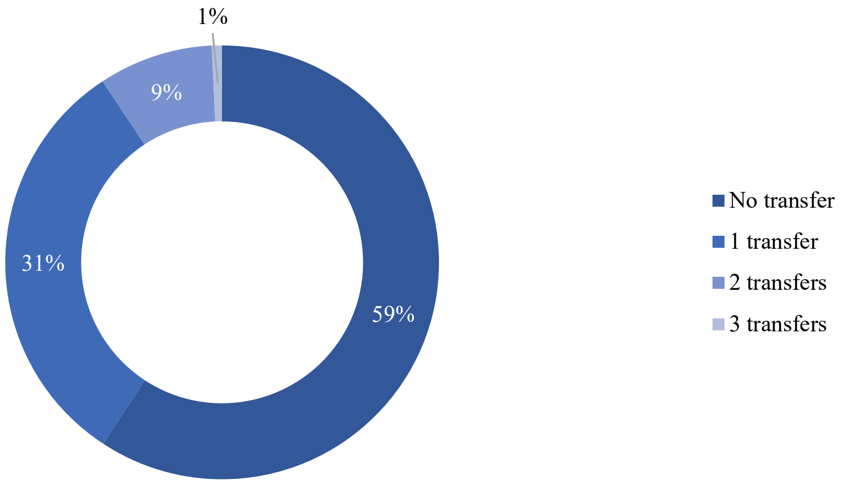
Source: based on CMSP (December 2013)

4.1.2. Current state of inter-modality in São Paulo

4.1.2.1. Number of transfers

Since various collective transport modes are available in the city, Paulistanos have the option of transferring from one mode to another or use different lines of the same mode during their trips. Around 41% of internal trips made by collective transportation in São Paulo include at least 1 transfer (CMSP, 2013). More precisely and as described on figure 5, 31% of trips include exactly 1 transfer, 8.5% include 2 transfers and less than 1 percent include 3 transfers or more.

Figure 5: Share of trips by collective transportation with transfers



Source: based on CMSP (December 2013)

Transfers can be a complicating factor for using public transportation. According to Rede Nossa São Paulo (2017), 11% of buses non-users mention the need to use another mode to complement a bus trip as one of the 3 main reasons why they do not use the bus.

Three main areas can limit the willingness of users to make intermodal trips with transfers. According to Fernandes (2007), terminals in integrated networks should offer sufficient levels of comfort and safety, both between passengers and vehicles and against robberies or violence, to be considered an acceptable alternative for the user to make a transfer. Second, terminal must be accessible to all, especially users with reduced mobility, and in any weather conditions. Finally, the process of planning an intermodal trip can be complicated because of lack of information and uncertainty on the reliability of the transport modes on each segment of the trip.

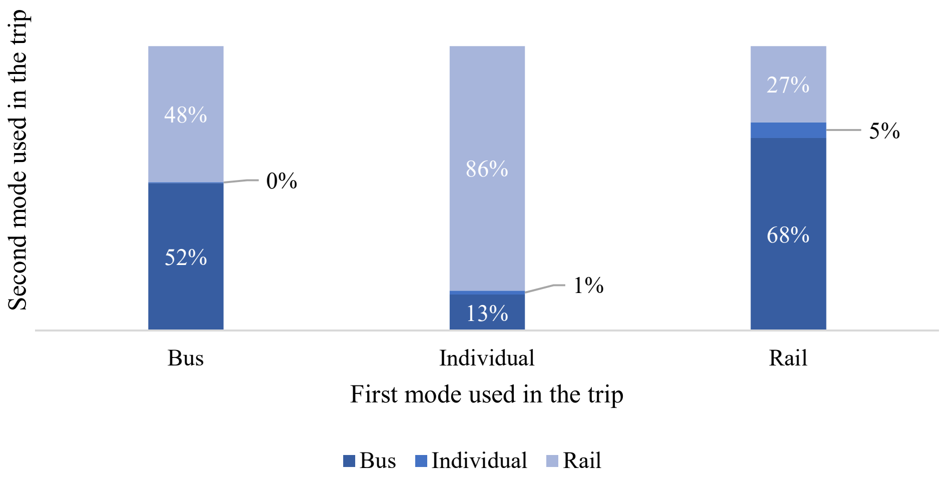
> "For example, when you have to climb stairs or to wait in uncovered places [...] there are cases where the transfer is hard or impossible." [INNOV_2]

> "The decision making is still very hard, you have to think about many things before and you are not sure if it's going to work. You don't know if the metro is working properly, you risk going to the metro and the metro stops. Many people still don't want to think about it and are still getting their cars and spending 3 hours everyday in the traffic jams." [MOB_SERVICE_2]

4.1.2.2. Modes in transfers

As explained in the previous section, transfers can be made inside the same mode (changing lines) or across modes. Figure 6 shows the breakdowns of the second mode used after a transfer depending on the first mode used in the trip. When an internal trip starts by bus and includes a transfer, 52% of the time the user takes another bus and 48% of the time they use rail as a second mode. 68% of rail users doing a transfer hop up on a bus afterwards, 27% change lines and the remaining 5% use an individual transport mode (car, motorbike or taxi) to complete their last mile. Commuters doing the first mile by individual transportation board 86% of the time a metro or a train and 13% take the bus.

Figure 6: Mode used after a transfer depending on first mode used



Source: based on CMSP (December 2013)

4.2. Transport providers in the municipality of São Paulo

In this section, we provide an overview of the transport modes available in the city of São Paulo. Each subsection deals with one transport modes. The main characteristics explored are the number of users, fleet size, regulative responsibilities, network and infrastructure. The main opportunities and obstacles faced by the actors of the industry are also presented.

4.2.1. Individual vehicles

The fleet of individual vehicles in the municipality of São Paulo reached 8 million vehicles in 2017 (SEADE, 2017). The RMSP consequently counts 1.46 inhabitants per individual vehicle. 5.6 million vehicles (70%) of this fleet are cars and 1.1 million (14%) are motorbikes or similar vehicles. As a result, there are 2.1 inhabitants per car and around 11 inhabitants per motorbike in São Paulo. Individual vehicles represent 84% of the total road vehicle fleet in the city. The fleet has been growing in last 5 years (from 7 in 2013 to 8 million in 2017) the number of inhabitants per vehicle dropped from 1.63 in 2013 to 1.46 in 2017.

The metropolitan region of São Paulo (RMSP) possesses the largest networks of highway in Brazil. It is also one of the highest quality networks of the country. According to CNT (2017), 46.6% of the highway extension in the State of São Paulo is in excellent condition and 31.2% in good condition. The RMSP is linked to the rest of the State of São Paulo and the other surrounding state by several highway systems shown in table 5. The different highway systems presented above are all linked by a circular highway of a length of 180 km named Rodoanel Mário Covas. This highway surrounds the RMSP and aims at diverting traffic from the dense urban center of the RMSP. (Investe SP, 2017).

Table 5: Highways originating in the Metropolitan Region of São Paulo

Name of the highway(s)	Regions linked
• **Anhanguera** • **Bandeirantes**	• North of the state of São Paulo • State of Minas Gerais • Center-West Brazil
• **Raposo Tavares** • **Presidente Castello Branco**	• West of the state of São Paulo • Sorocaba region
• **Presidente Dutra** • **Sistema Ayrton Senna** • **Carvalho Pinto**	• Vale do Paraíba • Northern coast of São Paulo • Rio de Janeiro
• **Anchieta** • **Imigrantes**	• Santos harbor

Source: based on Investe SP (2017)

In the city of São Paulo, the city hall is responsible for the roads through an inner department of the Secretariat of Mobility and Transportation (SMT). The Department of Operation of the Road System (Departamento de Operação do Sistema Viário [DSV]) is responsible for the signalization and law enforcement. The three main missions of DSV are to regulate the road system (for safety and productivity), improve the network (studies and infrastructure) and execute the regulation (Prefeitura de São Paulo, 2018). The Company of Traffic Engineering (Companhia de Engenharia do Tráfego [CET]) is responsible for the engineering and regulation of traffic and is a public and privately funded company and directly under the control of DSV [GOV_1]. The role of CET is to plan and implement measures for the operation of the road system especially with regards to safety and fluidity of traffic (CET, 2018). CET has four main areas of action: monitoring the traffic (cameras and radars), regulating (seat belt obligation), providing studies for infrastructure development and educating the population on transit.

Driving in São Paulo is a concern for most its inhabitants. The overall situation of traffic in the city is the aspect with the highest dissatisfaction among Paulistanos, scoring 2.8/10 in Rede Nossa

São Paulo's mobility survey (2017). Road infrastructure is also an important issue for drivers: the quality of the road gets a poor 3.0/10 satisfaction grade. Eventually, traffic laws are a source of discontent: the respect of traffic laws and application of the law by the authorities score respectively 3.3 and 3.6/10 in public satisfaction.

4.2.2. Public transportation

With 13.8 million daily trips, public transportation which encompasses buses, metro and trains represents 46% of motorized trips and 31% of all trips in the RMSP (CMSP, 2013). Public transportation is managed both at the State and City level in São Paulo. At the State level, the Secretary of Metropolitan Transports (Secretaria dos Transportes Metropolitanos [STM]) is responsible for the public transportation of passenger in the RMSP (Castelar Pinheiro, Frischtak, 2015). This organ was created in 1991 and depends on the Government of the State of São Paulo (STM, 2018). Its main missions include executing the state policies for passenger urban transportation, organizing and controlling the metropolitan public transportation system, giving concessions and permissions for transportation services, fixing prices and promoting public transportation modes towards the users. They are primarily in charge of the rail system (trains and metro) and intermunicipal bus network. For collective transportation at the city level, the Secretariat of Mobility and Transportation of the City Hall (Secretaria Municipal de Mobilidade e Transportes [SMT]) is responsible for municipal buses and special services.

> "The public transportation operated here starts with the public buses, large scale, all over the city." [GOV_1]

> "We have special services with mini-vans transporting people with disabilities." [GOV_1]

Dissatisfaction with public transportation is a pressing issue in São Paulo. Collective transportation is the fifth most problematic issue for Paulistanos behind health, safety, education and unemployment (Rede Nossa São Paulo, 2017). 24% of respondents to Rede Nossa São Paulo's survey ranked collective transportation as one of the three most problematic issues is in the city. Traffic and road quality follow in sixth and seventh place respectively. In the same survey, the satisfaction of users concerning public transportation as a whole (metro, train and bus) scores 3.8/10.

4.2.2.1. Bus

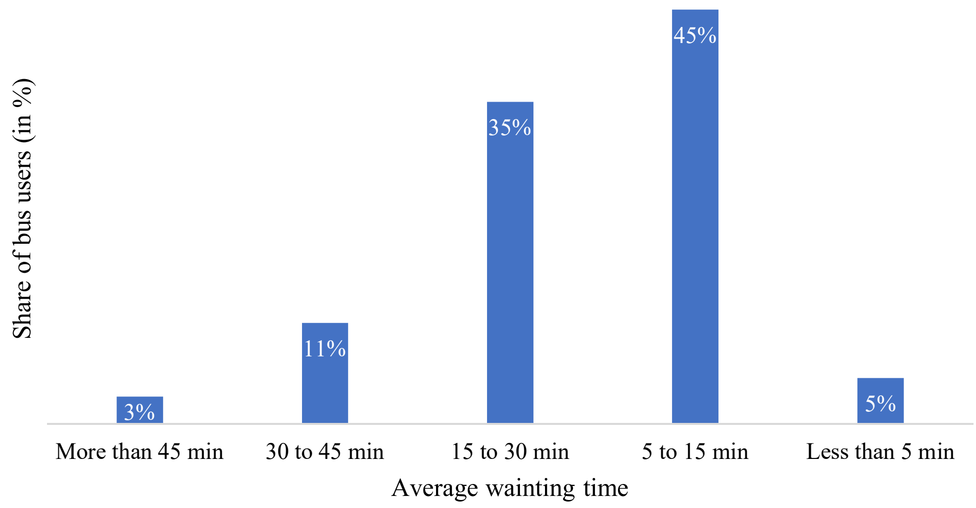
According to the CMSP (2013), 5.7 million bus trips are taken each day in São Paulo, representing 21% of all the trips in the city. The Government of the State, through a public company called Empresa Metropolitana de Transporte Urbano (EMTU), is in charge of the intermunicipal bus transportation and consequently operates in the outskirts of the city (STM, 2018). Since these buses do not operate for internal trips to the city of São Paulo, they will not be longer discussed in this study. The City Hall (Prefeitura de São Paulo) is responsible for the operation of the municipal bus system, inside the boundaries of the municipality, through a public company linked to the Department of Public Transports (Departamento de Transportes Públicos [DTP]) of SMT, SP Trans. SP Trans does not operate directly the fleet, they contract fleet operators to which specific operation areas are assigned [GOV_1]. In particular, the system is integrated into two subsystems: the structural subsystem with large scale vehicles to attend high demand zones, and the local subsystem with smaller buses that aliments the structural subsystem (SP Trans, 2018b). SP Trans' system includes more than 1.300 lines and 15,000 vehicles (SP Trans, 2018a). Recent

improvements of network extension, fleets and infrastructure considerably increased the reliability of the system.

> The system has been changing in the last 20-30 year in order to explore better the capillarity so that you can use larger buses in structural ways and larger roads with dedicated lanes to dodge traffic to have more confidence and reliability in the system with regards to time and delays.” [GOV_1]

Municipal buses are the most mainstream and economic transport mode in the city of São Paulo. According to Rede Nossa São Paulo’s survey (2017), commuters use municipal buses for three main reasons: they make economies thanks to the electronic ticketing (Bilhete Único) system (23%), it is the best alternative to accomplish their trip (18%) or they do not have a car (17%). Nevertheless, the bus system encounters some limitations with regards to effectiveness, reliability, comfort and safety. In the same survey (Rede Nossa São Paulo, 2017), 24% of non-users rank the long trip duration as one the three main reasons why they do not use the bus, 18% because it takes a long waiting time to board it and 10% because they do not find the buses punctual, and 31% because they find them too full. The average waiting time at a bus stop is 18 minutes. Figure 7 shows the distribution of waiting times for bus users in São Paulo. Safety related to robberies and attacks is the third most concerning factor for users in the bus, and safety related to sexual harassment is the fifth.

Figure 7: Distribution of users per waiting time at a bus stop



Source: based on RNSP (September 2017)

4.2.2.2. Rail

The rail network in São Paulo is divided into two subsystems: the metro and metropolitan trains. Mixt capital companies manage the subsystems, Company of São Paulo's Metropolitan (Companhia do Metropolitano de São Paulo [CMSP]) for the metro and Paulista Company of Metropolitan Train (Companhia Paulista de Trens Metropolitanos [CPTM]) for the trains (STM, 2018). The State of São Paulo has a majority participation in the capital of these companies that are subordinated to the Secretariat of Metropolitan Transportation of the Government of the State of São Paulo (Secretaria de Transportes Metropolitanos do Governo do Estado de São Paulo [STM]). When the metro network is mostly concentrated in the center of the city, the metropolitan train reaches suburban areas further away in the metropolitan region.

São Paulo's metro is the largest metro network in Brazil with 4.7 million users per day. The network includes 68 stations on 6 lines with a total length of 78km, exclusively on the municipality of São Paulo (CMSP, 2018). CPTM works on 22 municipalities of the RMSP. Its network has 7 lines for 270 km of extension with 106 stations for 2.8 million daily users (CPTM, 2018). In 2018, CPTM opened its most recent line, 13 – Jade, that reaches Guarulhos International Airport. Both systems are accessible everyday from 4am to 12am and until 1am on Saturdays (CMSP, CPTM, 2018). Both rail networks are fully integrated in terms of ticketing: one ticket give full access to the metro and metropolitan trains for R$ 4.00.

Figure 8: Map of railway network in the RMSP

Source: CMSP (2018)

Among Paulistanos, 13% declare using the metro as their main transport mode in the city and 4% declare using the metropolitan trains. Nevertheless, demands for improvement of the rail network are important from the population. When asked what measure could improve the public transportation in the city, building more rail lines and station is mentioned by 45% of respondents in their top 3, improving the quality of metro transportation is also mentioned by 45%, improving

the quality of the train service by 26% and offering 24h transport service by 23% (Rede Nossa São Paulo, 2017).

4.2.2.3. Taxis

According to ADETAX (Associação das Empresas de Taxi do Município de São Paulo [Association of Taxi Companies of the Municipality of São Paulo], 2015), around 34,000 taxis were circulating in the city of São Paulo in 2015. It represents 1 taxi for 305 inhabitants. São Paulo has a larger fleet than Rio de Janeiro (33,000) and 20,000 more taxis than New York City (12,800). 58 taxi fleets are operating around 4,000 taxis in São Paulo, approximatively 13% of all cabs. The remaining majority is made of either individual owners or co-owners of taxis and a taxi licence (ADETAX, 2018). In 2012, 110,000 daily trips per taxi were taken each day, less than 1% of all trips in the city (CMSP, 2013).

Taxis in São Paulo are regulated by SMT through the inner department DTP. The two main requirements to perform the service are, first, that the driver have the habilitation to drive a taxi (CONDUTAX) and, second, that the car be licensed (Alvará de Estacionamento) by the City Hall (Prefeitura de São Paulo, 2018a). For further regulative aspects, taxis follow the same rules as any given individual vehicle. The price of the rides is also set by the City Hall (Prefeitura de São Paulo, 2018b) at R$ 4.50 per ride plus R$ 2.75 per km and R$ 33.00 per hour. On Sundays, holidays and at night between 8 pm and 6 am, the price per km can be increased by 30%.

> "The SMT is also responsible for cabs regulation. The cars are operated by cab drivers that are organized in cooperatives. There are many ways to control them: the driver, the vehicle, licenses to upgrade as a warranty. Other aspects like safety and so on are regulated by the State of São Paulo as any other vehicle in circulation. Some irregularities only the police can issue. But the public interest that cabs represent that's regulated by the City Hall." [GOV_1]

> "Cabs and shuttles buses are also here *(linked to DTP)*." [GOV_1]

Two traditional ways allow to get a taxi drive: hailing the taxi in the street or by telephone through a call center. Nevertheless, recently a new model of ride-hailing by mobile apps started to provide a new way to access and pay for the service. The first player to introduce such a service in São Paulo was Easy Taxi in 2012 (Gomes, 2017). Other private players entered the market since (ex: 99 Táxis) Most taxi hailing mobile apps enable to call a taxi, follow its position while it comes get the passenger, follow the trip in real time and pay either by credit/debit card or by cash. In 2018, the City Hall of São Paulo launched its own taxi hailing app, Táxi SP (Olhar Digital, 2018). While Táxi SP includes most of the features of the other apps, it additionally allows taxi drivers to offer a discount up to 40% on the price of the ride. The project was developed by the Department of Innovation of the City Hall to offer to passengers guarantees on the license of the drivers and more safety.

> "The Department of Innovation of the City Hall is directly involved in the app Táxi SP for cabs, inspired by a similar project in Rio. But I did not follow very closely this development. I think it is a good initiative for taxi drivers." [GOV_2]

4.2.3. Ride-hailing

Recent technological disruptions in the private rides industry gave birth to ride-hailing services. Clewlow and Gouri (2017) give a comprehensive definition of such services: *"the common feature of ride-hailing services is the ability for a traveler to request a driver and vehicle through a smartphone app whereby the traveler's location is provided to the driver through GPS. With the support of GPS technology, digital maps, and routing algorithms, users are provided with real-time information about waiting times."* These services were introduced in Brazil in 2014 when Uber entered the market in Rio de Janeiro and São Paulo. The features available in São Paulo are,

for most apps, the ones described in Clewlow and Gouri's (2017) definition. When it comes to the platform, it is interesting to mention that most app also include a desktop interface and corporate services.

> "You can order any of the service available in your city either by desktop or mobile app or corporate platforms." [INNOV_1]

São Paulo is the most important city in the world for ride hailing both in terms of users and fleet. Between 22 and 26 million rides are accomplished each month in São Paulo. Since ride hailing companies are not extensively sharing data on their userbase, it is difficult to have a precise number of users in the city of São Paulo. The largest ride hailing company, Uber, claims to have more than 20 million users in Brazil (Uber, 2018). The second largest player, 99, claims 14 million users in Brazil (99, 2018). According to Rede Nossa São Paulo (2017), 2% of Paulistanos declare ride hailing to be the transportation mode they use with more frequency. Similarly, data on the fleet of ride hailing company is scarce. Nevertheless, São Paulo is known to be the city with the largest ride hailing fleet in the world. Uber has more than 500 thousand active drivers in Brazil (Uber, 2018). According to Folha de São Paulo, 150 thousand operate in the State of São Paulo, and the majority of them are in the Greater São Paulo (Folha de São Paulo, 2017). 99 says to have more than 300 thousand drivers and taxi drivers in Brazil (99, 2018)

> "São Paulo is the biggest city for ride hailing in the world" [INNOV_1]

> "Out of my head, the last numbers I had for the largest player was they were doing 16-18 million rides per month in São Paulo. The second largest had 5 to 6 and the third a third of the size of these." [INNOV_1]

Ride hailing is a new kind of services that appeared in São Paulo in the 2010's. The low prices offered by these companies made it very attractive for users. The usage patterns for private drivers are experiencing an important shift since the introduction of those services. First, they gained large number of taxi users attracted by low prices and additional features. Nevertheless, most of the growth of ride hailing apps is due to the creation of a whole new market. Most ride hailing users were not users of taxis or private drivers before the introduction of the apps. Users call for ride for their daily occupation such as shopping and going out. Yet, a large segment of the rides is first and last mile rides to reach a bus stop or a train or metro station, where the geographical extension of Uber's fleet is a strong competitive advantage.

> "Ride hailing did steal a lot of rides from taxi drivers, but they created a huge new market. People that were not even considering this kind of service started considering because of the price." [RIDE_HAIL]

> "For the first time, people started considering leaving their cars and go with Ubers or taxis." [RIDE_HAIL]

> "If you need to buy something, you don't need to take your car out of the garage and go to the supermarket." [RIDE_HAIL]

> "Now that we have the ride hailing option, we have a real integration between ride hailing and public transportation. Especially the last-mile trips. This works well in the further parts of the city." [RIDE_HAIL]

A dozen ride hailing apps are currently operating in São Paulo. Uber is a clear front runner in this market, followed by 99. Cabify and Easy Taxi, which belong to the same group (Maxi Mobility) are smaller. After the four main players, a longtail of smaller players specialized in niches. For example, Lady Driver offers trips only for female drivers and passengers (Lady Driver, 2018).

Brazil is a key market for ride hailing companies due to it size, and since São Paulo is the biggest city in Brazil, the competition among actors is fierce. Players with a first comer advantage (Uber and 99) are leading in market shares, but the size of the market enable actors with smaller market shares to achieve large userbases. First and last mile ride is a particularly key segment for ride hailing company and is dominated by Uber due to the wide geographical extension of its fleet in São Paulo.

> "Nowadays we have 10 or 11 operators sharing data with us [City Hall of São Paulo]." [GOV_3]

> "They need to win and are winning in LATAM, especially in Brazil. That makes it hard to win in ride hailing here because of Uber and 99." [RIDE_HAIL]

> "Brazil is so huge that we can be a really big company, being third or fourth in market share, because they have so many rides here." [RIDE_HAIL]

> "When you see the hit maps in most cities, especially in São Paulo, when all the app like Cabify, Easy and 99 are really concentrated in the center, Uber is really spread all over the city. They are the only app that got all the range of the city. It's really interesting because Uber wins a lot in the last-mile trips, from your house to the metro station or the metro to your house." [RIDE_HAIL]

The ride hailing market is regulated by the SMT, for two main reasons. First, the apparition of the first ride hailing service created conflicts with taxi operators concerned about loosing their market share and which resulted in the ban if ride hailing services. Nevertheless, the strong support of the population for these services forced public to create regulation to make it operate. Second, the City Hall is responsible for regulating the usage of the road, which was intense by ride hailing companies. Public authorities came up with a regulation forcing ride hailing operators to pay a tax on road usage and share data on their rides. The data therefore collected helps the City Hall

calculating the tax to be charged, and to monitor the services with low development and operation costs and risks.

> "It's our responsibility, and this department chairs a comity, to exert the micro-regulation concerning apps […] and they should also provide some data on mobility which is important for us." [GOV_1]

> "The problem was that 90% of the population uses and approves the service but on the other side taxi drivers are complaining because it is gaining their market share and the city council banned the service." [GOV_1]

> "We came up with a new approach in SP, saying that we regulated the usage of the road, the infrastructure of the city, which is our responsibility. That is why our regulation is named 'of the intensive usage of the road'." [GOV_3]

> "With the apps it's much more delicate, because in terms of regulation, we were not this prepared when the phenomenon came." [GOV_1]

> "Any operator can operate in São Paulo, but they have to ask for authorization of the city hall first. The authorization implies to develop an API to share the data of the cars and the races with us. […] Another rule is that each kilometer of race is taxed, in a range between 10 and 36 cents depending on the intensity of the usage of the road within the hour. So, there is a progressive taxation of the usage of the road." [GOV_3]

> "First, it provides the data to charge for the usage of the road." [GOV_3]

> "We try to assess behaviors and patterns of the service and then combine data with the tax on services and the cameras of the city. It makes us much more efficient than with people on the street. Also, with that approach, all the maintenance and development of the IT is kept with the operators, what make it more efficient since we just have to access the data, we don't collect it, and for safety too since we don't keep it with us." [GOV_3]

4.2.4. Biking and bike-sharing

Biking as a transport mode presents two main specificities. First, it is an active mode, which means the user uses their own energy to move the bike. Consequently, cyclists need a particular equipment. Second, biking requires special infrastructure to ensure a sufficient level of safety for cyclists. This is especially true in São Paulo where traffic is outstandingly dense. The SMT is in charge of the bike infrastructure (bike lanes and bike ways) and signalization. The bike infrastructure is growing in São Paulo, on the road, for parking and for changing clothes afterwards. The infrastructural improvement is the first factor fueling the grow of biking in São Paulo.

> "Every mode has specifics, like bikes need to have a special lane to be safe." [MOB_SERVICE_3]
>
> "Somebody with a bike or a scooter should define it as their main vehicle because you need specific clothes and protections." [INNOV_1]
>
> "When we talk about active mobility, besides the bike sharing, we are also responsible for all the signs in the city, lanes, bike lanes, crossroads." [GOV_1]
>
> "Today, there are 400km of bike lanes in São Paulo, the vast majority of commercial buildings have a parking area for bikes – some of the most modern ones even have changing rooms to take a shower." [BIKE_SHARE_1]
>
> "The infrastructure of the city allows biking to become an alternative to individual cars, ride hailing or public transportation." [BIKE_SHARE_1]

São Paulo possesses one bike-sharing system with docks, called Bike Sampa. Three main actors are responsible for the system. Tembici is the operator, in charge of planning of operating the system. The bank Itaú is the principal sponsor and provider of visual identity. The technology belongs to a Canadian provider, PBSC.

> “Tembici is an urban mobility company with biking as a main focus. It manages a bike-sharing service, Bike Sampa” [BIKE_SHARE_2]

> “Tembici is in charge of planning the system – studies of the city plan, definition of the location of the stations based on various directive rules – and the operation of the system – logistics, maintenance, etc.” [BIKE_SHARE_2]

> “The technology belongs to a Canadian company, PBSC, and Tembici is their partner on all Latin American projects. There is a factory in Minas Gerais where the bikes are manufactured, and the stations and software are imported from PBSC.” [BIKE_SHARE_2]

> “Itaú is the sponsor of the project, that is why the bikes are orange and the brand is present wherever they are.” [BIKE_SHARE_3]

Bike Sampa proposes two main services: short rentals in the city center – with durations up to a couple hours – and long rentals in peripherical areas for overnight rentals. The system currently has more than 3,000 bikes available and 270 docks. The strategy of network expansion changed recently from a network of large expansion with stations far from each other to a denser less expended network where each station is located approximatively 300 meters away from another station. The objective is to increase the usage of the service.

> “An interesting thing in São Paulo is that in the expended center there is a short duration service, but in the peripherical zones of the city there is a long duration service, for example in Tiradentes terminal.” [BIKE_SHARE_2]

> “In the long duration rental, the user can keep the bike for up to 12 hours without additional charges. Hence the user can go home with the bike, sleep with it at home and go back to the train station in the morning to give the bike back.” [BIKE_SHARE_2]

> “Today in Bike Sampa we have 3,100 bikes. 2,600 bikes will be in the expended center with 270 station and there will be 5 terminals of long duration with 500 bikes in total.” [BIKE_SHARE_2]

> "It is a great shift compared to the previous Bike Sampa network, which had a lot of stations spread with few trips because the density is very important for the success of the system. The decision was to reduce the coverage to achieve that density of stations, to be successful to get new sponsorships and widen the system afterwards." [BIKE_SHARE_2]

Complementarily to the dock service offered by Bike Sampa, new dock-less bike-sharing services are appearing in São Paulo. These systems allow the user to leave the bike wherever they finish their trip and to pick it up where the previous user left it. The bikes are localized and rentable through a mobile app. Two players are entering São Paulo in 2018, the Brazilian company Yellow with 20,000 bikes and the Chinese company Mobike, starting with 2,000 bikes (Mobilize, 2018)

> "Dock-less bike-sharing companies are entering the market in São Paulo." [BIKE_SHARE_1]

Bike-sharing systems respond to a very similar regulation from the City Hall than ride-hailing services. They have to share data on their fleet with the City Hall, yet they are not taxed on road usage but only for stations. Another requirement is to integrate the electronic ticketing system (Bilhete Único) to the service, at least to unlock the bike. This requirement will be challenging to implement with dock-less systems in the short run, but it should be overcome easily when mobile validation with NPC technology for the Bilhete Único is implemented in the long run.

> "The bike operators, dock-less or with docks, must also ask for authorization, provide an API and share data with us. Today they don't have a tax for the usage of the road, but they have one for the installation of the stations and the supply of each dock-less bike. It is a really small fee that does not really make a difference for them." [GOV_3]

> "We have a lot of contact with the city halls concerning the licences to install the stations." [BIKE_SHARE_3]

> “The regulation obliges the bike sharing systems (with or without docks) to enable unlocking the bikes with the BU. We are not sure if this regulation will work out. For the stations it works well, but for dock-less bikes, it brings a big burden on the systems and the hardware on the bike. It would make them more expensive and it would be a bigger problem if they are stolen.” [GOV_3]

> “I am not really optimistic with this system, but in the future, the BU will not require a card, it will work with a smartphone and it won’t be an issue anymore thanks to NFC or QR codes.” [GOV_3]

São Paulo presents numerous opportunities for biking to grow in the future. First, the average commuting distances are fit for biking. The integration of bike sharing system with other modes, especially rail, enable first and last mile rides. The increasing development of the infrastructure makes it easier and safer to ride a bike in the city. The growing mediatization of the benefits of biking and the 2018 truck drivers’ crisis contributed to a shift in mentalities towards more active mobility in the city.

> “Today, Paulistanos does on average 7.8 km from home to work each day, this distance is totally bikeable. The potential of São Paulo is really strong.” [BIKE_SHARE_1]

> “The question of inter-modality is important. For example, there is a large station in Largo da Batata, next to the Faria Lima bikeway. We observe a very high usage from people going out of the metro to work biking. The more intense use comes from inter-modality in peak hours in the mornings and afternoons.” [BIKE_SHARE_2]

> “The development of the cycling infrastructure is also key, since there are many problems of safety in traffic. When the infrastructure increases, so does the number of bikes.” [BIKE_SHARE_2]

> “Biking is a subject more and more discussed. People answer, the press talks about the benefits of biking for the city and public health. This information is bringing a change in thinking.” [BIKE_SHARE_3]

> "During the strike *[of the truck drivers]*, we got a record usage. In the last few months, the usage decreased a bit compared to the peak of the strike, so some people went back to using their cars. But sales of long-term plans and fidelity increased, and the average usage is higher than before the strike. So, we perceived that many people who were doing trips by bus or by car now opt for biking. […] We can conclude that the strike brought a change in mentality and that is was sustained." [BIKE_SHARE_2]

Yet many obstacles are still to be overcome for biking to become a major transport alternative. Biking suffers prejudice concerning safety on the road, for robberies and attacks, and especially for bike sharing systems, vandalism is a concerning issue. The importance of individual cars in the city create a competition for bike-sharing systems and biking infrastructure for public space against parking spots and car lanes. Eventually, the hilly geography of São Paulo is a major obstacle for biking.

> "Many people still have prejudice about biking in the city. Many of them act rationally: living in dangerous regions, without cycling infrastructure, some buildings do not have parking spots or do not even accept bikes. Obviously, the hills are a problem, São Paulo is full of hills." [BIKE_SHARE_1]

> "Bike-sharing companies suffer a lot from *Custo Brasil:* violence, vandalism on the bikes. In these schemes, all around the world, the loss level is very high." [BIKE_SHARE_1]

> "There is a big cultural challenge. People opt many times for the car even for short distances, and this could be switched to biking or even walking really easily. Since cars are predominant, many people stand against bike sharing stations which use space where they could park. We have to struggle for public space against individual cars." [BIKE_SHARE_3]

5. Findings

5.1. Understanding of the concept of MaaS of mobility actors in São Paulo

This section aims at evaluating the comprehension of mobility actors in São Paulo of the concept of MaaS before they were presented the definition from König et al. (2016) introduced in section 2. While most interviewee were aware of the concept, the definitions they provided varied from König et al.'s (2016). The attempts of definition of MaaS by the interviewees are presented in table 6 (only 6 interviewees attempted to give a definition of MaaS before being presented with the concept). Three main topics stand out among mobility experts in São Paulo when asked what their understanding of the concept of MaaS is: property, inter-modality and demand orientation.

Table 6: Attempts of definition of MaaS

Author	Definition
König et al. (2016)	"Multimodal and sustainable mobility service addressing customers' transport needs by integrating planning and payment on a one-stop-shop principle"
RIDE_HAIL	"A company that offer a MaaS platform is one that can address all your needs in terms of mobility from any way. So, if you need to go to point A to point B, it will offer you different options to move from one point to another. If you need to move something, it will offer you an option to move this to you. If you need something to be bought, it will offer you a way."
INNOV_1	"For me, the central point of MaaS is the property of the vehicle. The property is not to the user but to another company that for example builds the car and offers it as a service."
INNOV_2	"I imagine it is a large database that could unify the data from all transport modes trying to make them more agile in terms of distance and cost."
GOV_2	"The citizens don't have to own a car or the bus or any kind of transport. They can use an app and call for service and ideally from a public administration point of view, this would be integrated with public transportation systems and not just a competitor let's say."
BIKE_SHARE_1	"I think it is a platform trying to make various forms of urban mobility communicate. I think inter-modality in the city is ideal."
MOB_SERVICE_2	"The way we see MaaS is that, when a passenger or a citizen is going to move around the city, they don't want to worry about which kind of transport they are going to use."

Source: König et al. (2016), interviews

Interviewees consider that there is a shift for mobility users from a model of owning mobility assets (like cars, motorbikes, bikes) towards only using them to accomplish a trip. Here, users can

either use directly an asset – for example renting a car or a bike – or use a mobility service, such as ride hailing, and indirectly use the asset (in this case, the car is driven by a third party, the driver).

> "We are developing this service in a way that will create a culture of having mobility as a service rather than owning assets." [MOB_SERVICE_3]

> "The central point of MaaS is the property of the vehicle. The property is not to the user but to another company that for example builds the car and offers it as a service." [INNOV_1]

> "The citizens don't have to own a car or the bus or any kind of transport. They can use an app and call for service." [GOV_2]

The consequence of the shift in property model is increasing opportunities for inter-modality. The rationale is that users see transport modes as a mean to achieve a trip rather than an end in itself. Hence, they want to use the most efficient option to reach the goal of going from one point to another and the mode used to do it is a secondary preoccupation of users. Other mobility needs like shipping or shopping can also be substituted by services independently of the mode. Combining modes in the same trip can be the most efficient way to fulfill the users needs.

> "The way we see MaaS is that, when a passenger or a citizen is going to move around the city, they don't want to worry about which kind of transport they are going to use. […] It enables citizens to use different modes of transportation to do that journey." [MOB_SERVICE_2]

> "For me, a company that offer a MaaS platform is one that can address all your needs in terms of mobility from any way. So, if you need to go to point A to point B, it will offer you different options to move from one point to another. If you need to move something, it will offer you an option to move this to you. If you need something to bought, it will offer you a way." [RIDE_HAIL]

In order to enable inter-modality for users, interviewees understand that a MaaS platform would create links among various transport modes. The platform operator could gather data from transport operators to optimize inter-modal trips.

> "I think it is a platform trying to make various forms of urban mobility communicate. I think inter-modality in the city is ideal." [BIKE_SHARE_1]

> "I imagine it is a large database that could unify data from all modes trying to make them more agile in terms of distance and cost." [INNOV_2]

The third output of the understanding of mobility actors on MaaS is the strong focus on the user. They picture MaaS services as a way to bring value to the end users by providing additional services on top of pure transportation, alternative mobility options and strong quality of service.

> "It's something related to a customer service you deliver. A structure that would focus on the consumer and the service you provide to them." [GOV_1]

> "It is to bring value in the process of moving people, provide new benefits and new ways to commute based on solutions that are not necessarily trips." [MOB_SERVICE_1]

5.2. Potential characteristics of the MaaS scheme in São Paulo

This section aims at providing the possible options of core characteristics available in São Paulo and that would enable the adoption of a MaaS scheme. Four subsections have been explored in detail. First, we identified the potential players that could take part in the MaaS business ecosystem as defined by Kamargianni and Matyas (2017) and the relationships they could entertain. The second subsection focuses deeper on the integration of payment, a key characteristic of MaaS identified by König et al. (2016), and the options a MaaS coordinator would have when trying to provide an inter-modal payment service to unify transport modes. Section 5.2.3. explores the

existing technologies that could enable MaaS operations in São Paulo and the expected technological evolutions that could impact the MaaS environment in the city in the short and medium run at the light of König et al. (2017) work on technologies in a MaaS scheme. Eventually, the last subsection explores the demand orientation of the MaaS scheme in São Paulo, a key characteristic observed by Jittrapirom et al. (2017), with a focus on the potential levers to focus the service on the needs of the users and the potential benefits of the system for São Paulo's citizens.

5.2.1. MaaS business ecosystem

As explained by Kamargianni and Matyas (2017), MaaS schemes involve several actors in the different layers of the MaaS provider business ecosystem. First, this section aims at identifying the potential players of the core business layer of the MaaS provider, *in extenso* what transport providers could participate to a MaaS scheme in the city of São Paulo. Then, it will attempt to understand the connections between the core business partners that enable inter-modality for the user. Four options for the focal company of the MaaS business ecosystem, in charge of enabling, scaling and growing the MaaS scheme (Holmberg et al., 2016), are later explored. Eventually, regulative aspects of the MaaS scheme are investigated since they are part of the broader business ecosystem of the MaaS provider and play a significant role in the city of São Paulo.

5.2.1.1. Core business partners: transport providers

Transport providers are the main core business partners of the MaaS service provider (Kamargianni & Matyas, 2017). Among this group, a key transport provider that could participate to the MaaS scheme is public transportation. It is obviously the largest transporter in the city (see sections 4.1.1. and 4.2.2.) and their participation is considered a key success factor for the MaaS

platform. All data concerning these transport modes are public and available to all by law, which would make their integration relatively straightforward.

> "I think these kind of integration goes through public transportation." [RIDE_HAIL]

> "I think that the transport modes that are run by the government or that the government has a participation or a say in, are easy to get in. The government can provide the data as open platform. In Brazil there is a law on information access which forces governments to provide those data to the society." [GOV_2]

The growth potential of ride hailing and car sharing services makes them really attractive players to include in the system. In particular, their ability to perform efficiently first and last mile trips to link individual journey starting or ending points to the public transportation grid is a strong advantage they can provide to a MaaS service. Nevertheless, since they are often managed by private company, the ability of a MaaS coordinator to get data from them for the operational integration is uncertain.

> "The shared cars should be included since in the long run they are going to take private cars out of the roads." [INNOV_2]

> "Now that we have the ride hailing option, we have a real integration between ride hailing and public transportation. Especially the last-mile trips. This works well in the further parts of the city." [RIDE_HAIL]

> "The issue comes from private operators that don't have the same obligation and see the data as their private asset they don't want to share because of competition and fear of getting customer information from their systems. You must make it clear to them that this is a business opportunity that can bring the benefits and more passengers." [GOV_2]

For similar reasons as ride hailing, biking would fit well in a MaaS platform in São Paulo. It is really efficient for first and last mile trips. The potential of biking in São Paulo is considered large especially in intermodal journeys. Two kind of actors could be included. First, bike sharing platforms and especially Bike Sampa, which already has all data on stations and bikes available openly. Dock-less bike sharing systems could similarly be included, yet since the services are extremely recent in São Paulo, we cannot state it with certainty. Second, individual bikes – be they privately owned or rented by the users – can play the same role as shared bikes in accomplishing parts of a journey.

> "The shared bikes should participate also. They work well principally with high capacity modes that have fixed itineraries. If there was a service that make the user go to the metro it is great for the metro because they want passengers. […] If these companies bet more on passengers willing to come by bike, it gives incentives and contributes to less pollution and the health of the user." [INNOV_2]
>
> "For bikes and electrical scooters, there is still some room to put them in the journeys." [INNOV_1]
>
> "I think bike renting companies could be one of the players. The clients use electric bikes to commute, but when they do a longer trip or when it rains they hail a taxi or a ride or use their own cars. They incentivize inter-modality." [BIKE_SHARE_1]
>
> "- Bike Sampa would surely participate. There are no problem concerning sharing the position of the stations and the numbers of bikes live. [BIKE_SHARE_2]
>
> - Actually, this data is already available in the site and app for the users" [BIKE_SHARE_3]

5.2.1.2. Relationships between core business partners for inter-modality

The availability of multiple transport providers and modes gives the opportunity to users to engage in inter-modal journeys (Muller et al., 2004). The first enabler to inter-modality is the integration of the networks of each provider with the others. The planning of the public transportation

networks in São Paulo significantly improved in that direction to avoid the superposition of lines from different operators and improve the coverage of the services. Additionally, new services like bike-sharing or ride-hailing plan their network in order to operate together with other transport modes, in particular with high capacity modes. They can efficiently fill gaps in the public transportation network, especially for first and last mile trips.

> "In the majority of cases, the transport modes work well together […]. There was a time in the past when there was a dispute for passengers between modes, with bus lines on top of metro lines, etc. But I think that it is resolved now and does not happen anymore." [INNOV_2]

> "Urban mobility goes much further than only public transportation, and more and more the modes are converging. Public transportation goes with ride-hailing, with biking. The user gets the best solution for the moment they are living." [MOB_SERVICE_1]

> "I think the bike sharing network goes well with the rest of the system. They are close to bus corridors, metro and train stations. They always try to integrate with other transport modes in the coverage." [BIKE_SHARE_2]

> "Now that we have the ride hailing option, we have a real integration between ride hailing and public transportation. Especially the last-mile trips." [RIDE_HAIL]

On top of the integration of the networks, a physical integration of transport modes is required to enable efficient transfers from one mode to another. This aspect appears to be one of the weakness of the mobility system in São Paulo. First, public transportation facilities are not always adapted to receive users of active mobility users (cyclists, scooters). Second, some transfers are not adapted to all users, especially not to people with mobility difficulties, and to all conditions (ex: bad weather). The lack of homogeneous mapping of the transfer areas with detailed information on accessibility harms the feasibility of transfers.

> “The public transportation is not adapted to receive bicycles for example. It’s not something that is easy to carry a bike in the metro for instance.” [RIDE_HAIL]

> “A weakness of apps that suggest transfers is when for example you have to climb stairs or wait in uncovered places. They do not take into consideration the needs of everyone.” [INNOV_2]

> “For transfers, I don’t think any of the operator has all of it mapped, each has a niche they work in. It lacks a superior chamber that would be the manager of that platform. It would take some architects to map the cases where the transfer is hard or impossible.” [INNOV_2]

The third enabler of inter-modal trips is the integration of data from various operators and the availability to commuters. The MaaS coordinator should be able to collect data (times, routes, delays) from all transport providers in order to produce inter-modal itineraries for the end-user. Uncertainty on the reliability of transportation in São Paulo, due to delays, traffic intensity or availability of spots, is a complicating factor for the efficient restitution of data to the users. Another obstacle lies on the security of data, both of the user and the companies, and requires robust and safe IT infrastructure.

> “We need data from each agency or transport provider.” [GOV_2]

> “I think the difficult part is to find the right moment when the mode is available to the traveler. Planning for transportation in São Paulo will not work consistently.” [INNOV_1]

> “How do you combine your information so that the users know that the next bus is going to arrive in X amount of time and the closest bike station with free bikes is there, or if you have dock-less bikes where they are, or if you call a cab how long will it take to get to you? Or if you can make the decision in advance like taking the metro and book a bicycle at your final metro station so that you are sure that when you arrive a bike will be waiting for you over there and you don’t risk having a journey that takes much longer than expected.” [GOV_2]

> "There are companies involved, there is the question of the security of the users' data to solve and how to contract it and how to deal with it." [GOV_1]

5.2.1.3. MaaS business ecosystem focal player: the coordinator

As explained by Holmberg et al. (2016), MaaS schemes are build around a unique combined-mobility service provider, known as the coordinator. The coordinator mission in to enable, scale and grow the MaaS service principally by gathering data from all transport providers to build inter-modal trips for the users, by charging the end-user and redistributing the revenues to the transport providers and by provide the platform to access the service. Homberg et al. (2016) present the options for the coordinator: public, private or a public and private collaboration. This section studies these options in the context of São Paulo. Additionally, an alternative business-to-business model is presented.

The first option for the MaaS coordinator is a public instance. The main advantage of a public coordinator is their ability to get access to data from all players, even if required to use coercive levers. They can additionally adapt the legislation more efficiently to the needs of the service if they are in charge of it. An instance of the Government of the State could be a suitable option, yet in order to be representative a forum of various public players would be needed.

> "I think the public players have a better leverage and more power to have access to these platforms and have access to the data, because the government can force the private operators to give access to the data for the transportation system to run." [MOB_SERVICE_2]

> "Anyways, there will be looks of the public power to create a regulation, so maybe it has better be a public responsibility. Now for the reality of São Paulo, judging on how the roles are defined, maybe it should happen at the Government of the State, I'm not sure." [INNOV_2]

> "I think that to reach our goals, it would require a common authority involving all the cities of the metropolitan area. That comes from the international experience." [GOV_1]

Several disadvantages of a public coordinator yet seem to appear in the context of São Paulo. The accumulation of players in the public space of urban mobility and coordination issues among them slow down decision making and development of new services. The lack of resources allocated by public players on the development of new projects is also a major barrier. Eventually, the uncertainty related to 2018's elections reduces the willingness to engage in long term projects.

> "In the context of SP, I think it would be difficult to wait for the city hall to take charge of it. I know they have plans to operate the transport system in another way, but they face a lot of difficulties to change things. The system does not depend only on the desire of the mayor and the secretary but also on the players that provide PT, the State and the bus concessions. It is a very complicated economic arrangement and the city hall cannot just take it for her and provide a new service." [INNOV_1]

> "If you integrate the public and private transportation systems, I don't see a scheme where the money is managed by the public side, especially now with the difficulties on fiscal issues." [GOV_3]

> "In the same time the city doesn't have the resources to develop the tools to enable MaaS. I think the role of the city is to be a platform. The government should do everything they can to create a transportation platform based on open data and open standards and then the private operators must also provide their data on the open platform and their APIs should be open." [MOB_SERVICE_2]

> "It could come from the public sector, but there are elections soon, so no one is willing to make big moves." [MOB_SERVICE_3]

Private initiative to build a MaaS scheme in São Paulo can also be explored. The first option to be considered is that a transport provider aggregates other modes in their service. Ride-hailing companies are trying to take that path globally by adding new services like delivery to their model.

They offer the most complicated service to operate and hence have an advantage on third parties. Their size and resources would provide them with levers to develop such a service.

> "In my view, this is the most difficult service to nail in the all MaaS, because there is a lot of variance in the size of the fleet, the dispatching, etc." [RIDE_HAIL]

> "I think the companies to be in charge of the service would be the ride hailing companies. They are the biggest and would have a stronger funding position to back this project. When you see the huge players worldwide doing this, they are basically ride-hailing companies." [RIDE_HAIL]

> "I think all big players in mobility and ride hailing are aiming for MaaS. They know it and need to do this kind of integrations. They could probably start by doing it on their provider platform and then bring these providers to their platform." [RIDE_HAIL]

Yet, the willingness of a transport provider to dedicate time and resources to developing a MaaS scheme may be limited by their existing strategy and operations. Industry experts are more confident in a third party MaaS provider which would not be a transport provider. The third party would have a role of data integrator and interface between mobility providers and users. Additionally, a third party could more efficiently to find ways to operate in the mobility system as it is rather than trying to change the operations of existing transport providers. The main limiting aspect of a third-party coordinator is the low level of maturity of start-ups in São Paulo that reduces their ability to come up with holistic large-scale solutions.

> "It's really unlikely that one of those providers be able to connect all of the others because they have their own interests and problems and must run their operations. […] They don't have the resources and the time to do it, so it would be someone else that would integrate all the data from all the providers to enable the citizen to have this seamless multimodal experience." [MOB_SERVICE_2]

> "I think the provider of the service should operate in the public space as it works today […]. This company would interface for payment and would require the times of the transport modes, their locations, utilization. It should not ask the public and private transport providers to connect with each other because they will not." [INNOV_1]

> "I don't think start-ups are at this level of maturation yet, of thinking integrated transports in the reality of São Paulo. They are more focused in punctual or local questions." [INNOV_2]

In order to get the best of both options, a partnership between private and public player can be considered. The public actors could set the conditions, especially in terms of open data and software, to enable the private sector to innovate and develop a new service. Ideally, the forum of all transport agencies of the RMSP should be consulted in spite of administrative barriers. The idea of a public-private partnership (PPP) contract would be too rigid to enable flexibility and innovation in the service.

> "The city should put the software infrastructure in place so that the private sector can leverage the platform to create the service for the citizens." [MOB_SERVICE_2]

> "Ideally it would be a public-private arrangement, led not only by our municipal agency but I think the forum. There is a network of transport agencies of the 37 cities of the RMSP. There would be a lot of bureaucratical and political challenges when trying to setup a system like this. But to create a long-lasting change, it would be an interesting forum." [GOV_2]

> "When it comes to innovation and you have to adapt quickly, I don't think a PPP would be the best solution since it's a kind of contract that is really tough and hard to change and improve." [GOV_3]

Another approach that could be explored for the MaaS scheme would be a business-to-business (B2B) model, where the coordinator would be a private company providing a MaaS platform to other companies for their employees. Since the employers cover the costs, the service ends up free

of charge to the users. The fact that the employers have access to their employees' behavior in the trips can also improve the safety and reliability of the system. Yet, the scale of a B2B MaaS model could hardly reach the one of a business-to-consumer (B2C) and inclusion issues may arise (unemployed, employee of a non-client company).

> "Companies are the main starting point. We decided to offer a management platform for mobility to companies. The users are the employees and they are clients after the company. The company is the first step." [MOB_SERVICE_3]

> "We want to offer a free service to the end user, a with our costs it is really difficult to do that for individuals since we don't want ads either. Today, the companies pay the bill." [MOB_SERVICE_3]

> "If you carpool on a platform your boss gets access to, you are not going to do anything bad. The question is what makes the company opt in, and there each company has its on answers." [MOB_SERVICE_3]

5.2.1.4. Broader MaaS business ecosystem layer: regulation

The MaaS scheme necessarily exists inside its broader business ecosystem (Kamargianni & Matyas, 2017) and in particular in the given regulative environment of São Paulo. Mobility is a public sector's responsibility by law and a MaaS service coordinator would mandatorily comply with laws and regulations in order to operate. The public sector does not have necessarily to provide the service to the end user, but it will be an active actor of the MaaS ecosystem to issue regulations adapted to the system and make sure they are respected in the MaaS scheme.

> "The constitution states that it is our responsibility to take care of it basically. So, I don't see a private actor able to steer the wheel. We could have a mixed concertation instance that the State would be obliged to hear and take inputs from, like we have with the civil society." [GOV_1]

> "But we still have not only the faculty to deal with transportation and mobility but the responsibility towards us, and this is given by our constitution. It says what is going to happen at the State level, at the city level and the federal level. But it is written that we must – not only can – take care of it. I don't believe personally that the State should necessarily be the one that provide the final service, but it must be the head, the one that thinks what kind of society we want and what we should do to have this society." [GOV_1]

In the case of São Paulo, an important factor is the coexistence of two main public actors able to issue regulation in terms of urban mobility: The Government of the State of São Paulo and The City Hall of São Paulo. Even though their respective roles are set by law, political divergences among these instances can complicate the planning and implementation of the public mobility strategy.

> "The other thing that complicates the situation is that the high capacity modes (metro and trains) are subordinated to the Government of the State and the bus fleets to the city halls. It is different government instances which at some moment of the story are managed by different parties." [INNOV_2]

On top of regulating and issuing policy, the public sector can also set standards to provide a framework in which one or more MaaS platforms can evolve while complying to the overall vision for mobility of the public instances. An interesting example of such practice can be found in the Zona Azul initiative of the City Hall of São Paulo for parking mobile applications.

> "Maybe the city could on top of planning and executing everything, they could set up standards, goals and practices that maybe the private companies could create their own apps. A bit similar that what we did opening the GPS data for the buses or the Zona Azul parking service." [GOV_2]

> "Zona Azul is maybe an example. I began in the last city hall term so I did not follow too closely and I'm not an expert so…But as I understand they let know how the service should work with

> minimum standards and dos and don’ts, then private operators were able to create their own apps and services and the market dictated which one was the best after a few years of consolidation of the best apps.” [GOV_2]

5.2.2. Centralized payment for inter-modality

As depicted by König et al. (2016), being able to centralize in a unique interface the payment of all the transport modes included in the inter-modal journey the users accomplish is a key characteristic of MaaS providers. Jittrapirom et al. (2017) add that MaaS providers should also issue tickets and invoices for each mode. It is also relevant to stress that the MaaS coordinator must then distribute the revenue from the users to the transport operators.

> “Ticketing and charging, financial aspects of how you integrate different payment and ticketing systems of different providers to enable citizens to pay once and distribute the revenue among all the players.” [MOB_SERVICE_2]

This section explores the levers a MaaS coordinator could activate to perform inter-modal payment and ticketing, the available means of payment for a MaaS service in São Paulo and the possible tariff options to be proposed to the end user.

5.2.2.1. Integration of multiple ticketing and payment systems

The electronic ticketing system Bilhete Único can be a strong basis to perform inter-modal payments in a MaaS system. Indeed, the Bilhete Único system includes the ticketing and payment of municipal buses, metro and trains in the city of São Paulo. It also enables to unlock shared bikes and aims at including the payment of bike-sharing service in the short run.

> “One way to do it could be to build around the Bilhete Único platform, to allow people to pay with the same card and same payment system.” [GOV_2]

> "The service that the City operates is integrated in terms of payment. Metro and buses can be paid with Bilhete Único, and the user pays a little less when they take two rides in a row. The bikes, shared service, also aims at using the Bilhete Único." [GOV_1]

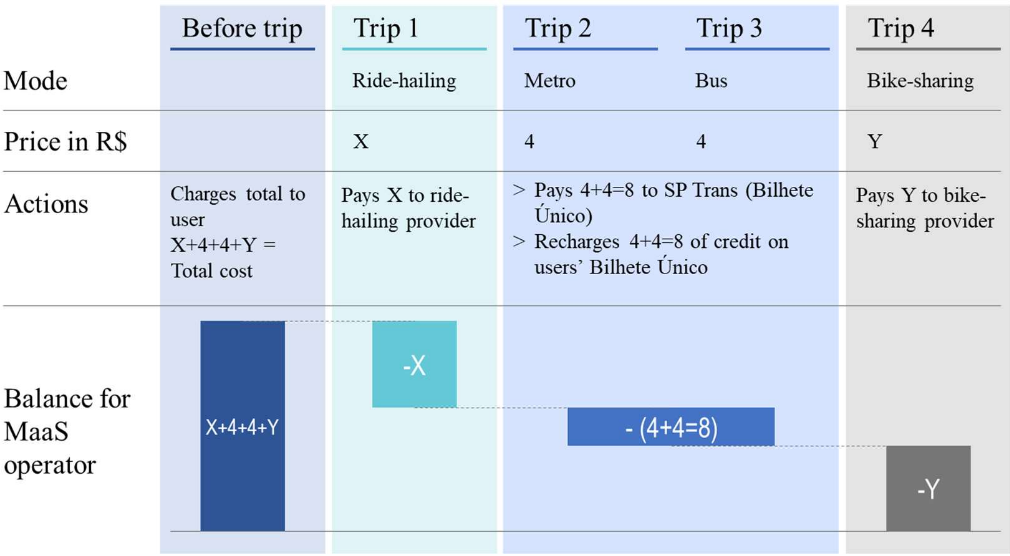
To include the Bilhete Único into the MaaS platform, a straightforward way would be to allow the MaaS platform to recharge credit on the Bilhete Único. This can be possible through a single accreditation from SP Trans, which is already given to various third-party rechargers. This way, each time a user takes an intermodal trip and pays for it, the platform would charge the necessary credit to accomplish the parts of the trip done by public transportation and charge it to the user on top of the charges for other services like ride hailing.

> "The MaaS operator could be accredited by SP Trans to charge credit on the Bilhete Único, like dozens of other already existing apps." [INNOV_2]

> "With ride hailing, the model would be that instead of doing their ride, paying the driver and buy credit in the metro station, the user would go out of the ride with their Bilhete Único already recharged. In a future phase, the user could also use the credit they have on their Bilhete Único to pay for a ride hailing ride." [MOB_SERVICE_1]

After gathering the money from the users, the MaaS operator would have distribute the revenue to each transporter according to the service they provided during the intermodal trip. Figure 9 shows an example of how the payment integrated with Bilhete Único and redistribution of the revenues could be performed.

Figure 9: Example of payment and revenue distribution model in an intermodal trip



Source: Author

5.2.2.2. Potential means of payment for the MaaS service

By integrating credit and debit cards to the platform, the MaaS service enables cashless payments for all transport modes. By recharging the Bilhete Único with a credit or debit card on the platform and paying ride hailing and bike sharing by card, the MaaS operator can operate with the legacy payment system of all transport providers without any adjustment. Additionally, the risk is low since credit and debit cards payment terminals are mature technologies with reliable providers.

> "If I can make a comparison with ride-hailing apps, one of the main points of MaaS is you don't make any transactions with money." [INNOV_1]

> "The easiest way to integrate would be to allow credit cards to enter the public transportation system rather than ride hailing on the Bilhete Único." [GOV_3]

> "The payment is easier: the payment system providers work really well." [RIDE_HAIL]

Nevertheless, the specificities of São Paulo regarding payment should be taken into consideration. Large segments of mobility users do not have access to bank account in São Paulo and consequently do not have a credit or debit card. Most transport providers enable cash payments but the integration of cash payments on the MaaS platform would require adjustment to the charging model defined in section 5.2.2.1.

> "The payment is something very interesting in LATAM. Most people don't have bank accounts" [RIDE_HAIL]
>
> "Today, credit cards are available for people with bank accounts. A large part of public transportation users is of class C, D and E. They do not have access to bank accounts." [MOB_SERVICE_1]
>
> "With the Bilhete Único, a credit card is not necessary, you can recharge credit on it with cash." [INNOV_2]

The MaaS platform should also be able to provide the users with digital invoices for their trips. Ride-hailing and bike-sharing services already include this feature, but public transportation does not. Even if it would not be technically complicated to achieve, levers to authenticate digital invoice for public transportation must be activated first.

> "Receiving invoices should be done on the platform." [INNOV_2]
>
> "I don't think it would be difficult to digitize invoicing for public transportation but dealing with the authenticity of that would probably have to be solved. Anyone can send an email saying anything but authenticate that email deals with digital signatures. It is not yet very popular here. There are systems that work with it but not a lot of people have an e-CPF to authenticate something, to check the public and private cryptography keys and making sure of the validity." [GOV_1]

The last challenge arising from means of payment and that a MaaS scheme should take into consideration is that a large part of public transportation is subsidized by companies for their employees. The money dedicated by companies for this use cannot be used for other mobility services, especially the private ones.

> "Half of the transportation are paid by the employers through Vale Transporte. That is specific to the PT system and can't be shared with other services because they receive benefits from the Federal law and pay less taxes on some issues." [GOV_3]

5.2.2.3. Available tariff options for the end-user

Pay-as-you-go is one of the most frequent tariff options available on MaaS schemes worldwide (Jittrapirom, 2017). Since all transport providers in the city propose such an option, it can easily be integrated in the MaaS platform. In particular, it would not require any negotiation with the transport providers to create new plans, especially with public transportation were the regulative barriers are important for such adjustments.

> "For now, ride-hailing just has a pay-as-you-go option." [RIDE_HAIL]

> "With the private transportation, you are able to create more tariff options and negotiate to create plans. Once again, for the PT it is impossible because you need legislation to change the prices and there are discounts programs for the poor populations. So, I think it would be more pay-as-you-go." [INNOV_1]

Nevertheless, the perspective of introducing pre-paid subscriptions deserves to be explored. Some players start implementing them. They could take the form of periodical pre-paid packages of trips. The details of the packages would make part of the MaaS provider strategy and depend on negotiations with the transport providers.

> "Uber is starting pre-payments in Brazil, the same way you add some credit in your phone on a pre-paid plan, to pay for Uber." [RIDE_HAIL]

> "When a user can use public transportation, rent bikes and cars, hail a cab or a ride, there is a package of trips you can offer them to pay monthly and they would get a benefit from that." [MOB_SERVICE_1]

Eventually, initiative to provide free services or rewards can be considered too. There is a trend in the market for free mobile apps and users tend to cherish more and more this specificity. The provider would hence get their revenue from sharing user's data rather than charging for usage. Feature like similar to the municipal initiative to financially reward cyclists could also be included to incentivize the use of the platform and get benefits on more costly transport modes like ride-hailing.

> "Yet, people are becoming familiar with free apps with excellent service, like Waze. They make their money from another way because the client gives you their data." [INNOV_1]

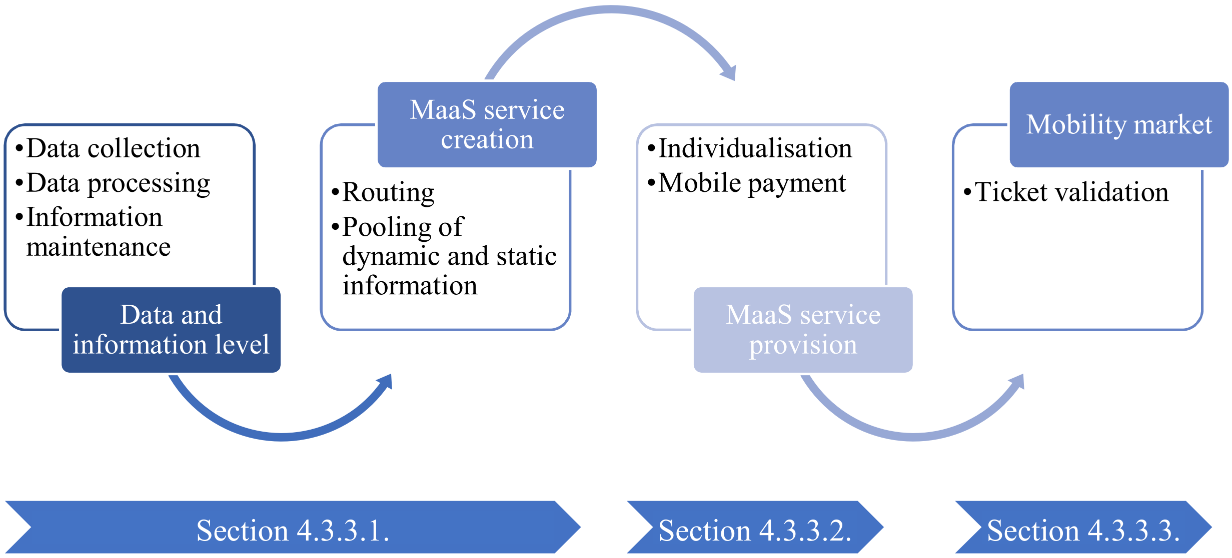
> "The law that created Bike Sampa aimed at stimulating biking in the city, prioritizing it on top of public transportation. The problem was that public transportation users are financially subsidized by the City Hall. If a user does not use public transportation, the City Hall does not have to pay that subsidy. The City Hall wants to stimulate the people to use bike by rewarding them financially with a part of the economy they would generate by biking rather than using the bus." [MOB_SERVICE_1]

5.2.3. Enabling technologies for a MaaS service

König et al. (2017) identifies the steps of the MaaS providers value chain where technology is critical (see figure 10). This section first identifies the potential technologies for the data and information level of the value chain, in particular data collection and processing. Then it focuses

on the possible platform to provide the MaaS service to the user: Eventually it explores the technologies in the mobility market that could enable the validation of the tickets provided by the MaaS operator.

Figure 10: Technologies in MaaS value chain and section 5.2.3. overview



Source: adapted from König (2017)

5.2.3.1. Data and information levels for MaaS servicer creation: journey planning

The critical point for inter-modal journey planning is get access to data from various transport operators, especially on arrival time and duration of trips, and combine them to create itineraries. The most efficient method to gather this information is to work with open data with APIs enabling a third party (in this case, the MaaS coordinator) to access the databases of the transport provider. Public transportation and the bike-sharing system already have their databases open and free of access. Private transport providers, especially ride-hailing apps, should share the data with the

MaaS operator to be included in the scheme. User-generated data on traffic conditions or utilization of high capacity modes can also improve the decision-making on journey planning. The MaaS operator can rely on an external service provider for journey planning. Ride-hailing companies for example often rely on such practices.

> "Transport providers should use open data and open platforms that enables people to combine those data to provide a seamless experience to the consumer." [MOB_SERVICE_2]

> "All the data of public transportation is open. You don't have to sign any agreement. It's opened because we want people to develop solutions too. If a group of researchers or students develop a solution and need the data to see if it works, it should be open so that they can try. If they want to operate, then they must ask for the authorization for the API, tests must be made. But for tests, the data is open." [GOV_1]

> "Bike Sampa shares the map with the location of stations and the number of bikes in each station as open data". [BIKE_SHARE_2]

> "It should be an app like Waze that sends data during the trip, stores it in a cloud and enable the users to know in real time what the situation is. When a lot of people use such an app it is very efficient, it's a network effect." [INNOV_1]

> "For some ride-hailing apps, it's part third-parties, part the internal system. The time used to tell you how much the ride will cost often comes from Google Maps" [RIDE_HAIL]

An adapted IT infrastructure is mandatory to perform efficient journey planning. In São Paulo, all transport modes are equipped with GPS for real-time location and thank to their smartphone, commuters are also easily located. Additional features like sensors for the utilization of high capacity modes are also available. Software to track the mode used, especially for biking, can be used to reward the user. Optimization tools like connected sensors and the Internet of Things (IoT)

are not yet widely implemented though, due especially to the limited resources and capabilities of the public sector in a giant city.

> "All mobility services are based on GPS for the location of the user or the transport mode. I don't think connected objects, IoT already exists. […] Line 4-Yellow of the metro has the weight of the wagon that allows, based on an algorithm, to show on the screen where the user should go not to be in a full wagon. It is possible to that in buses, it's already a component of a part of the fleet, but it is not operating yet." [INNOV_2]

> "We developed a software to check if a user is effectively using a bike to generate a financial benefit. […] It would be a software that does the analysis of the movement of the user with speed, moves and the resources the of their smartphone to get a deep and safe analysis" [MOB_SERVICE_1]

> "We have the challenges that all Brazilian public managers face: lack of funds, a rigid judicial and legal system, unequal government capacities among carriers and public managers. Specifically, it is also due to the size of the city. We have over 100 thousand public servants, we have the challenge of discontinuity between one term and the other since when there a new mayor some projects are interrupt and don't go on. All of this creates an environment where some parts are really innovative along with areas that still have many challenges." [GOV_2]

To support large amounts of data to store and process, cloud computing is a key technology to scale digital services with no infrastructure costs. Combined to machine learning systems or big data technology, they enable a better knowledge of mobility pattern and can optimize journey planning.

> "Cloud computing helped us a lot because we can have infrastructures that grow as the volume of data grows. Hence, we don't need to buy huge infrastructure to process come data, we can increase our process infrastructure as data increases. Other technologies such as machine learning also help

us to detect events on the data, to understand what is normal for bus line, for streets, for a part of the town and what is abnormal based on the data we are processing every day.” [MOB_SERVICE_2]

“Big data and machine learning try to come up with the patterns of the traffic, how transit interacts with other modes of transportation. There are some private projects and we try to develop some private projects on this.” [GOV_2]

5.2.3.2. Platform for MaaS service provision

Two main options for the online platform for users can be considered: a mobile app or a desktop website. Mobile apps are unanimously preferred by interviewees. The ability to use the service from anywhere is a strong advantage over desktop. Nevertheless, a desktop platform in addition to the mobile app can also be developed for punctual uses.

“New mobility services principally use mobile apps. I think it is because of the portability. It’s this moment’s reality, everybody has their life on the phone and can buy on mobile at any time.” [INNOV_2]

“I have no doubt it would be on smartphones and apps. You can have also an interface for web and PC but 90% of the usage would be by smartphone.” [INNOV_1]

“Mobile is 95% of the requests. Desktop is good to have when you don’t have your phone. Especially when you’re working, and you know it, so you just stop your work and go order your ride on the website.” [RIDE_HAIL]

To increase the attractivity and usage of the MaaS service, integrating a chatbot system available on social media and able to perform at least some of the features of the mobile app can be an interesting option.

“Today apps don’t only compete for space between them but also with photos, videos, music… The most downloaded apps are social networks. Somehow, that’s where the users want to be. […] Why

> not bring a service where the user is, without downloading anything? Chatbots are developed for the user to use the service in the very social network. Depending on their service provider, they can also have exception in the pack of data too." [MOB_SERVICE_1]

A strong advantage of the mobile app is that it can be used to collect data on the users and pattern of usage of the service. Since each user is equipped with a smartphone, no additional investment in sensors is required and it can help in gathering qualitative information from the user on the service.

> "We can use the app as a data collection tool. Passengers have a lot of information about the bus system that are hard to capture even if we could deploy sensors. Like if the driver of the bus is driving properly or not. This kind of data depends a lot on the quality felt by the passenger." [MOB_SERVICE_2]

Basic features could include journey planning and live updates on the trip, with several options easily comparable. As discussed in section 5.2.2.1, the app should be able to recharge the Bilhete Único to perform inter-modal trips. Eventually, including safety features and alerts in a growing demand from users and transport providers in São Paulo.

> "I need to know the fastest way, with less transfers and cheapest that it can offer me. Or it can provide various possibilities like Google Maps. It has to give the times and places where there are transfers." [INNOV_2]

> "The app can recharge the Bilhete Único." [INNOV_1]

> "One thing that is really trendy right now in LATAM is safety features like Panic Button or share my ride features […]. Passengers and drivers are actively demanding features that give them the impression that they are being safe." [RIDE_HAIL]

When signing up on the mobile app, registration will be required. Most mobility services like bike-sharing or ride-hailing demand basic information on the user to create an account usually include name, e-mail, phone number, address, CPF, gender and age. The MaaS platform should be able to gather these pieces of information and provide them to the transporters in order for the user to get access to their services. Linking a credit card to the account in convenient for payment and reinforces the legitimacy of the account. Yet, mechanisms exist for users that do not have a credit card. The Bilhete Único in mandatorily linked to an ID and would have to be acquired prior to use of the MaaS service as depicted in section 5.2.2.1.

> "For bike sharing, it's basic information: name, e-mail, CPF and phone number. If they use the app, they need a credit card for the payment. If they do not have one, they can go to a customer service point to present an ID and proof of residence and pay by cash." [BIKE_SHARE_2]

> "In ride-hailing, since you can only pay with credit card, you'll always be requested to add a credit card before you can do your first request. By adding your credit card, you have to add your CPF. That gives you more trust in the registration. Apps also ask for basic information like date of birth, address, or Facebook profile" [RIDE_HAIL]

> "Recently we had issue with fraud. We had to cancel the anonymous card for Bilhete Único, you have to link it with a document. It's not very good for tourists…" [GOV_1]

Furnishing all the required information to use the service might generate difficulties for some users. Nevertheless, the transportation assets like bike or cars in ride-hailing are valuable and the service provider needs minimum information on the users to be able to trace them in case of accident or vandalism. In the Bilhete Único's system, numerous subsidies exist. They should be taken into account when recharging the Bilhete Único on the app and the documents that justify

these subsidies must also be provided by the user, who sometime encounters difficulties in delivering them.

> "Sometimes there are problems with the documents we ask to the users to rent a bike. I think those are really basic documents to rent an object of that price. The client also has the option of not renting a bike." [BIKE_SHARE_1]

> "Documents are necessary for Bilhete Único because there are many subsidies programs (school, elderly, disabled, etc.) and some data is necessary to prove tat the user can benefit from the subsidy. Asking for such information can create difficulties for a part of the population." [INNOV_2]

5.2.3.3. Ticket validation terminal in the mobility market

Public transportation mode, since they are high capacity modes, require the user to validate their ticket before boarding. In São Paulo, mobile validation is on the verge of being implemented. Technically, minor adjustments to the IT systems are necessary, but the bus fleet renewed in 2013 includes Near Field Communication (NFC) technology that would enable the validation with a smartphone. The main obstacle is not technological but business-related. In particular, the technology providers are perceived resistant to the change, setting barriers on the usage of their hardware products.

> "Technically, we already have the ability of introducing mobile validation in public transportation. The challenge is much more commercial and business-related." [MOB_SERVICE_1]

> "The main obstacle for implementing that is that our IT back office must be updated. We are developing a new IT system that will make possible to plug in new systems. I don't think it will take long before we use cellphones to validate. But with the new system with APIs in SP, the private companies will come up with new solutions to integrate systems since it's for their best interests." [GOV_3]

> "The reading equipment manufacturers are a bit resistant to it. They set some barriers. We understand it comes from a fear of loss of market, of market power. When we started this project, we thought they were only technology providers. Since they provide the technology, you buy a product and become its owner. Yet in this market it's not like that. You are the owner, but you do not decide what goes in and what happens with it. Since it is an extremely closed and conservative market with few manufacturers in the country, they have determined regions and established markets. Hence, it's hard to enter." [MOB_SERVICE_1]

The validation hardware present in buses and the metro is based on cloud computing and all novelties are built on top of the legacy system. Introducing mobile payment in São Paulo's municipal buses requires to include a single chip in the validation hardware. The operation is easier for the metro network since the number of validators is much smaller.

> "Behind the payment in the bus, there are the validators in the bus. They send data to a cloud refreshed every 40 seconds or so. All improvements come on top of that model. The latest news where the recharge of credit on the Bilhete Único by mobile app and the data go to the same cloud." [INNOV_2]

> "Technically, we would include a chip, a safety module in the reading equipment of the buses, in the train and metro stations, that would accept our payment mode. It's not necessarily a card, it could be a phone." [MOB_SERVICE_1]

> "The readers in the buses already have the ability to read NFC. […] I'm not sure for the metro, but anyways it is easier to change since they have 74 stations with 20 readers. For the buses, all the validators have been changed in 2013 and they read NFC. If we want to use QR codes, we need to update." [GOV_3]

Before mobile validation is introduced on the public transportation network, the MaaS system can rely on the Bilhete Único electronic ticketing system that has been on service for more than ten

years efficiently. The age of the system may nevertheless be an obstacle for further improvement of electronic ticketing.

> "I cannot oversea when the public services will be able to incorporate mobile payment, since BU work pretty well." [INNOV_1]
>
> "Since the Bilhete Único system appeared more than 10 years ago, there are already obsolete things in the technology." [INNOV_2]

5.2.4. Levers for customer centricity of the MaaS service

As explained by Atkins (2015), one of the main realizations of MaaS platforms is to put the user in control of their mobility thanks to customer-centered services. This section investigates potential levers for a MaaS coordinator to furnish a demand-oriented service in the city of São Paulo. Section 5.2.4.1. provides a panorama of the existing customer service tools used by mobility services in the city on which the coordinator can build to address its users' need for support. Section 5.2.4.2. explores the opportunities to personalize or customize the service to each user – a key characteristic of MaaS platforms according to Jittrapirom et al. (2017). Eventually, the last subsection aims at listing the potential benefits from the users' perspective of implementing a MaaS scheme in the city of São Paulo.

5.2.4.1. Customer success, service and support

The MaaS operator can build on the contact channels already existing in mobility services to provide customer service and support. Traditionally, customer service is performed by telephone or email linked to a call center. In-app chat or chat on a desktop website are also common practices for mobility services in São Paulo. WhatsApp also appear as a strong alternative due to its high level of usage among Brazilian smartphone users and convenience

> "For the customer, we only answer by email and phone, but most of them just send emails." [RIDE_HAIL]

> "The City Hall has three main forms of delivery such services. Through the 156 phone number, an app that we released one and a half year ago and through the website. […] Regarding the issue of mobility, we have been trying to concentrate everything on one platform. Many agencies have their own call-center, but we are in a project, it's our core strategy, to concentrate everything, have the same standards, procedure and data." [GOV_2]

> "The bike user can join our help center by WhatsApp, e-mail and a formulary on our site. We have a phone number, but we prefer that it comes by WhatsApp of formulary." [BIKE_SHARE_1]

Call center are driven mostly by labour but some attempts to automatize parts or all the customer service process through big data or bots' technologies are being gradually tested and implemented. The main barrier to fully implement such automatized processes is the continuing demand from the users for human assistance.

> "We still don't have big data, machine learning or any other platforms or interface to deal with the citizens. We would like to try thing like bots but don't have concrete plans so far. It would be great for efficiency and costs, but in the short and medium terms, we don't think it would work. Many citizens need human contact." [GOV_2]

Alongside the call center, most mobility services provide help content in self-usage for their user, in order to have them solving their issues alone and without mobilizing resources from the company. This is achieved thanks to Frequently Asked Questions (FAQ) databases and knowledge centers. If the user does not manage to solve the problem by themselves, they can call the call center to receive assistance from the service provider. The main obstacle for providing efficient

customer service, especially for public transportation operators, lies in that the demand for service from the users exceeds the capacity of action of the support teams.

> "Ride hailing apps have a knowledge base where you always try to make the users find the answer by themselves." [RIDE_HAIL]

> "After they join the call center, we treat the user's problem, be it a doubt or an issue with the bike." [BIKE_SHARE_2]

> "The problem is that the citizens ask for much more that we can deliver. We have a good system to receive the complains and request but our capacity to solve the issue the citizens have is not very high. It's better in some places than others." [GOV_2]

In order to limit the need from users to request assistance from a call center, mobility service mobilize user-generated content to ensure the highest quality of service as possible. In ride-hailing, the most common practice is the five-star rating of the drivers. For bike-sharing, users can spontaneously alert the system if the bike they used is damaged to fasten the reparation. In a general fashion, the MaaS operator needs to provide users with seamless ways to give feedback on their trips it can then forward to the transporters in order to improve the service.

> "The other thing is governance: automated mechanism ensure that they offer the passengers the service that we ant them to deliver. The main tool for that is rating. Then, for each city we set a minimum rating level that the driver can have to be able to drive." [RIDE_HAIL]

> "A specificity of this system is that the user can signal in the station if a bike has a problem. Immediately it will be locked on the dock. Then, the alteration central comes and rapidly fix the problem." [BIKE_SHARE_2]

> "To monitor you use the client to capture what happens by giving them ways to quickly contact you. On how to guarantee the quality of the service, it depends on if you give the public transportation

> information is useful to improve the service. Hence, they become a partner. That way, the public sector receives you as one that help providing a better service. You should not ask them to improve, they already have a lot of people claiming." [INNOV_1]

5.2.4.2. Personalization and customization of the MaaS service

Additional features customized by the user of the MaaS app could be integrated on top of the core service. In particular, users could synchronize their agenda with the app in order to prepare their inter-modal trips in advance. It would help them planning their weekly activities more efficiently and get information on when they can achieve in-trip activities.

> "The app could have a customization part. It would be a good opportunity for people to speed up their decision making. Then, it should show how long they are going spend in travel to plan if they have activities (reading, working, meetings) they can do during the trip. I think it is a good idea to connect it with your agenda. Additional integration would help to sell the app. Using voice would be ok too." [INNOV_1]

Data analysis on the user's pattern can enable automated personalization of the trips or suggestions for optimization of their MaaS experience, either in terms of gain in time, in money or in comfort. Nevertheless, the technologies for such applications are still immature and could only be implemented efficiently at a large scale in the medium run.

> "Without a doubt, working with data is a genuine willingness for us and generate intelligence thanks to data analysis, including about the movements of the user to create intelligent services to improve their experience. When we know that a user does a frequent trip, if we perceive that we can optimize that route with a new mode to have a cheaper more enjoyable trip. We want to offer that." [MOB_SERVICE_1]

> "But using a full AI would require a few more years to get ready." [INNOV_1]

Another way to personalize the service to the client is to offer premium memberships. The MaaS operator could follow the example of the most recent initiatives in that direction implemented in ride-hailing. Premium members could have advantages in terms of rapidity of service, higher quality or exclusive customer service.

> "With Easy Taxi, if you had a Club Easy Gold plan you would have a better customer service. In Cabify, if you had a "purple plan", you would have a preferred dispatching: your dispatch would go first in line. Uber has Uber Select also with a premium service." [RIDE_HAIL]

5.2.4.3. Potential benefits of the MaaS service to end-users

The MaaS service aims primarily at improving the mobility conditions of the users by providing them a wide range of benefits. In the case of São Paulo, where commuting times are especially long, the main advantage the MaaS platform should be able to offer is a gain in time. This includes first the duration of the trip, but also the decision-making in planning an intermodal trip.

> "I think in São Paulo it is a matter of time more than modes." [INNOV_1]

> "We just serve the user with options. We show them that they can change their mobility just by looking around. People don't have time or patience to change the planning of their daily routine." [MOB_SERVICE_3]

The second main benefit the MaaS app should be able to provide is an increased overall satisfaction of the user on the urban mobility system. First, it could help the users in understanding what mode is most adapted to their trip and discover modes they do not usually take. The centralization of payment in a unique interface can considerably simplify the experience of the user. These benefits are the driver of a sustainable change in the mobility patters of the citizens.

> "Once there is a real model of MaaS implemented here, I think people will start considering other types of transportation, rather than only car or public transport. I think these platforms will show to passengers how they can benefit from other types of transportation for different types of commutes that they need to do." [RIDE_HAIL]

> "Integrate the services and also integrate the payment. If a person only with a BU can do the first mile by bike, piece of the ride in a small electric autonomous vehicle that does not exist here, and you take the subway ad then you do the last mile by bike again. Of could I would increase the satisfaction." [GOV_1]

> "There is an effort to establish a carpool, it is not only a question of money. If we can make them try and they see a benefit, they would have a chance to change." [MOB_SERVICE_3]

Eventually, by incentivizing active transport modes and especially biking and bike-sharing, the MaaS platform can contribute to the improvement of the health and well being of its users. First because these modes are not pollutants and improve the overall quality of the air of the city, and second because the users do some exercise to commute.

> "If these companies bet more on passengers willing to come by bike, it would give incentives to contribute to less pollution and to the health of the user." [INNOV_2]

5.3. Findings summary table: core characteristics proposed for a MaaS scheme in São Paulo

Table 7: Core characteristics proposed for a MaaS scheme in São Paulo

Core characteristic	Main findings for the urban mobility system of São Paulo
MaaS business ecosystem	• Transporters: bus, metro, suburban trains, ride and taxi hailing companies, bike sharing systems • Increased opportunities for inter-modality by developing transfer accessibility and sharing data on timetables and trips • 3 options for B2C coordination: public, private or public and private cooperation. Alternatively, a B2B MaaS service can be considered • Cooperation with public sector for compliance to regulation and setting standards and norms
Centralized intermodal payment	• Integration of multiple ticketing and payment systems by building on the Bilhete Único system and distributing revenues to transporters • Means of payment: first debit and credit cards, and later cash. Provision of digital invoices • Tariff options: pay-as-you-go, periodical subscription. Possibility to implement a free service or rewards by monetizing users' data
Technologies	• Intermodal journey planning based on shared data with APIs, GPS localization, IoT (connected sensors) and cloud computing • Mobile app as main user interface possibly complemented with desktop interface and social networks chatbot. Required account creation with personal and payment information • Mobile app used for journey planning and booking, live journey following and recharging Bilhete Único • Ticket validation supported by existing systems (Bilhete Único, validators or mobile app) in the short run. Possible introduction of mobile ticket validation with NFC in the medium run
Customer centricity	• Customer support through call centers, social networks (especially WhatsApp) or e-mail. Customer success ensured by exhaustive FAQ section and user-generated content • Service customization by integrating with user's agenda. Optimization of routes and trips thanks to usage patterns. Possibility to introduce premium memberships with advantages • Potential benefits for users: gains in commuting time, overall satisfaction and health and environment

Source: Author

6. Discussion

This section provides first an explanation of the meaning of main findings of the case study and their importance for the field of study of MaaS and the urban mobility system of São Paulo. The findings of the study are related to previous work in the second subsection, in particular to the

characterization of existing MaaS schemes proposed by Jittrapirom et al. (2017), Holmberg et al. (2016) and König et al. (2016), in order to highlight the similarities and differences of MaaS scheme in São Paulo compared to other geographies. The third subsection attempts to evaluate the comparability of a MaaS scheme in São Paulo with schemes in different cities, especially in developed countries, and calls for an adaptation of the concept of MaaS to better fit the specificities of developing countries.

6.1. Interpretation of the findings

The main interpretation of the findings that can be drawn out of the study of São Paulo's urban mobility system (section 4.1.) and the potential characteristics of a MaaS scheme in São Paulo (section 5.2.) is that São Paulo possesses the main conditions to implement a MaaS scheme. This conclusion can be illustrated at the light of König et al.'s (2016) definition of MaaS schemes: *"Multimodal and sustainable mobility services (i) addressing customers' transport needs (ii) by integrating planning (iii) and payment (iv) on a one-stop-shop principle (v)"*. Potential actors to participate in the service are identified, in particular transporters, and their operations and network are already partly integrated to provide multimodal and intermodal mobility solutions *(i – Section 5.2.1.)*. Building on the existing customer service channels, a MaaS service in São Paulo can fulfill the users' needs with increased satisfaction and new benefits *(ii – Section 5.2.4.)*. Opportunities to develop centralized payment are embodied by the Bilhete Único system for public transportation and available means of payments (especially credit and debit cards) for private services *(iv - Section 5.2.2.)*. Eventually, the technological environment and capabilities of the urban mobility system of São Paulo is sufficient to plan intermodal journeys *(iii – Section 5.2.3.)* and centralize all contacts between the MaaS provider and the user in a single interface *(v – Section 5.2.3.)*.

Two main factors contribute to the importance of these findings. First, as observed in introduction and section 4.1., the urban mobility system of São Paulo is characterized by long commuting durations and saturation of both the public transportation infrastructure and the road (traffic jams), resulting in numerous negative externalities among which productivity loss, bad environmental impacts and deteriorated quality of living. Yet, the findings of this study indicate that there is potential for optimizing the utilization of the urban mobility system thanks to a MaaS scheme encouraging intermodal and cleaner mobility, reducing decision-making and journey durations for the users and promoting active transportation modes. The second factor is that these findings reveal a business opportunity to develop a MaaS service in São Paulo. As detailed in section 5.2.1.3., various types of actors can undertake the project to integrate transporters' data to perform inter-modal journey planning and centralize their payment terminals, be they public or private. The findings also identify some barriers or requirements (ex: authorization to recharge Bilhete Único, serve credit/debit card users) to implement a MaaS service in São Paulo.

6.2. Comparison with previous MaaS scheme characterization attempts

This section puts into perspective the findings of the potential characteristics of a MaaS service in São Paulo by comparing them with existing schemes over the world characterized in the literature. To perform the comparison, three schemes have been selected: UbiGo (Gothenburg, Sweden), Whim (Helsinki, Finland) and Optimod (Lyon, France). Three main reasons explain the selection of these three schemes. First, they are widely investigated in the literature on MaaS by several authors (Sochor et al. [2014, 2015], Holmberg et al. [2016], König et al. [2016], Jittrapirom et al. [2017]). Second, they present a wide variety of different characteristics, in particular with regards to coordination, tariff options, functionalities and personalization/customization, which provides

the largest exhaustivity to the comparison. Eventually, they have differences in their setups, both geographically (three different countries) and in time (starting dates ranging from 2012 to 2016). This section first lists the similarities among the schemes with regards to the four main dimensions identified in the findings (actors, payment, technologies and demand orientation) and then exposes the differences.

Table 8: Comparison of core characteristics of selected MaaS schemes and São Paulo case

Core charac.	Case of São Paulo	UbiGo (Gothenburg, Sweden)	Whim (Helsinki, Finland)	Optimod (Lyon, France)
MaaS business ecosystem	• Transporters: bus, metro, suburban trains, ride and taxi hailing companies, bike sharing systems • 3 options for B2C coordination: public, private or public and private cooperation.	• Transporters: public transportation, bike sharing, car sharing, car rental, taxi • Private coordination	• Transporters: public transportation, bike sharing, car sharing, car rental, taxi • Private coordination	• Transporters: public transportation, bike sharing, suburban trains, parking • Public coordination
Centralized intermodal payment	• Integration of multiple ticketing and payment systems building on the Bilhete Único system and distributing revenues to transporters • Means of payment: first debit and credit cards, and later cash. Provision of digital invoices • Tariff options: pay-as-you-go, periodical subscription.	• Integration of multiple ticketing and payment systems by building on a smart card system • Means of payment: credit cards • Tariff option: monthly subscription	• Integration of multiple ticketing and payment systems with ePay • Means of payment: credit cards • Tariff option: pay-as-you-go and monthly subscriptions	• No centralized intermodal payment included
Technologies	• Intermodal journey planning based on shared data with APIs, GPS localization, IoT (connected sensors) and cloud computing • Mobile app as main for of user interface. Required account creation with personal and payment information • Mobile app used for journey planning, live info. and recharging Bilhete Único • Ticket validation supported by existing systems	• Intermodal journey planning based on shared data with APIs, GPS localization • Mobile app with required registration with personal and payment information • Mobile app journey planning, booking, ticketing, invoicing and payment	• Intermodal journey planning based on shared data with APIs, GPS localization • Mobile app with required registration with personal and payment information • Mobile app journey planning, booking, ticketing, invoicing and payment	• Intermodal journey planning based on shared data with APIs, GPS localization • Mobile app with required registration with personal information • Mobile app for real time info, prediction of congestion, journey planning, booking, alerts and airplane timetables
Customer centricity	• Customer support through call centers, social networks (especially WhatsApp) or e-mail. Customer success ensured by exhaustive FAQ section and user-generated content • Service customization by integrating with user's agenda. Optimization of routes and trips thanks to usage patterns. • Potential benefits for users: gains in commuting time, overall satisfaction and health and environment	• 24 hours customer support by mobile app and phone • Service personalization by setting monthly budget with top-up & roll over • Potential benefits for users: gains in commuting time, overall satisfaction and health and environment	• Service customization by integrating with user's agenda • Service personalization: cancelation, change subscription, expense top-up • Potential benefits for users: gains in commuting time, overall satisfaction and health and environment	• Service personalization by stating favourite modes and indicating ownership of a personal bike • Potential benefits for users: gains in commuting time, overall satisfaction and health and environment

Source: based on Jittrapirom et al. (2017)

The first similarity among the selected MaaS schemes lies in the actors of these schemes, in particular in the transporters. Public transportation and bike-sharing services are systematically present in the platform and could also be key players of a MaaS service in São Paulo. As a result, public and private actors collaborate in the existing schemes and could potentially in the case of São Paulo as explored in section 5.2.1. When it comes to payment, UbiGo proposes a monthly tariff and Whim a pay-as-you-go option and monthly packages in the same model as defined in the findings in the case of São Paulo. Whim relies on a e-payment system for credit and debit cards as proposed in section 5.2.2.2. and UbiGo incorporate a smart card for payment and validation on a similar model as what the Bilhete Único could offer in a MaaS system. Regarding technologies, unsurprisingly mobile apps are the support for the users' interface in all cases. All apps can provide the core services of the MaaS platform: intermodal journey planning, booking and real-time info. Ticketing, payment and invoicing are also present for UbiGo and Whim. GPS technology is also unsurprisingly included in all schemes. Eventually, Jittrapirom et al. (2017) consider the three schemes are demand oriented since they aim at optimizing the users' benefits and include demand responsive transport modes. The study of the similarities among the three selected schemes and the proposed characteristics of a MaaS service in São Paulo shows that they converge on the core characteristics of the MaaS service proposed by König et al. (2016): inter-modal journey planning and execution, emphasis on sustainable transport modes, mobile-internet-based, and user-centric.

Nevertheless, some differences can be identified between the selected schemes and the potential one in São Paulo. First, the coordination of the service remains an open issue. Holmberg et al. (2016) identify the options for the role of the public transportation operators, either as the

coordinator or a collaborator in the MaaS ecosystem. Real MaaS cases show that both options exist: Optimod relies on the public authority to assume the role when UbiGo and Whim are based on third parties to provide the service. Similarly, all schemes do not necessarily include the same transport modes: Whim and UbiGo include taxis, car sharing and car rental whereas Optimod opted for integrating with parking lots for personal vehicles. The scheme in São Paulo could include ride-hailing as a major actor, which is not present in the other selected schemes. By being publicly coordinated, Optimod offers a free service whereas the other schemes are paying services. Even if all services rely on mobile apps, the functionalities they offer differ. Optimod offer additional features such as airport departure and arrival times and UbiGo provides a 24 hours customer service for example. Personalization and customization are also a source of differentiation between apps: Whim includes the integration with the user's agenda as proposed for the scheme in São Paulo (section 5.2.4.2.), but also social network sharing. Ubigo proposes to integrate a monthly mobility budget for the users to monitor and manage their spending.

Jittrapirom et al. (2017) also identified in their comparative study of MaaS schemes in Europe and North America that there are *"certain attributes unique to case studies, such as features that can influence trip decision" (1)* and that *"certain schemes go further to offer perk features" (2)*. The findings of our comparison attempt also indicate that the differences among schemes lie mostly on the exhaustivity of available transport modes proposed to users *(1)* and the additional features the app is able to provide *(2)* to improve the quality of the service.

6.3. Comparability and adaption of the concept of MaaS for developing countries

Acknowledging the comparison performed in the previous section, this section attempts to explain the similarities and differences among schemes. Eventually, it calls for an adaptation of the concept of MaaS to fit the mobility conditions of São Paulo and other developing countries in general.

As shown in section 6.2., most MaaS schemes are similar on the core characteristic of MaaS. One way to explain the convergence in the proposed features is that these services try to tackle the same pain points form the user's perspective. Kamargianni & Matyas (2017) identified the main pain points of intermodal journey planners: non-inclusion of all available modes in a given area, no design of intermodal itineraries, different ticketing systems and payment methods for each mode. Hence, MaaS services are trying to come up with solutions for each of these pain points: intermodal journey planners including as many modes as possible and centralization of payment and ticketing.

The other explanation we can provide has regards to the common demand orientation of the schemes identified by Jittrapirom et al. (2017) and Atkins (2015). MaaS schemes initiators see the pain points presented above as a business opportunity (when they are private aggregators) or a lever to improve citizens satisfaction (when they are public players). In order to seize these opportunities and considering their objective (sales or increased satisfaction), MaaS providers uniformly aim at creating services with the highest value for the end-user.

Finally, the convergence in technologies (GPS, mobile apps and payment) can be explained by the technological context of the period when these services are launched, as described by Cohen-Blankshtain and Rotem-Mindali (2013). MaaS schemes are recent and were all born in the 2010's when mobile internet is booming, GPS is a mature technology, and most users are equipped with

credit and debit cards and increasingly purchasing online. MaaS providers are consequently capitalizing on technological and market trends to build the infrastructure supporting their service.

The differences exposed in section 6.2. may also be explained by several factors. First, the different degrees of inclusion of transport modes can be understood first by the setup of the urban mobility system where the MaaS scheme operates and by business partnership issues. MaaS providers operate in a given urban mobility system and depend on the existing transport modes in the system to build their offer. They are hence limited by the availability of the transport modes in the area and their reliability, which they must first evaluate prior to integration of the mode in the service as explained by Matyas and Kamargianni (2017) in their stated preference experiments for MaaS plans. The second explanation of what modes participate in a MaaS service comes from the ability of the MaaS aggregator to have the transporters operators in the project. They have to convince the transport operators that the MaaS scheme is a business opportunity and not a threat to their existing business model and may face barriers when negotiating inclusion of a given mode. Kamargianni and Matyas (2017) consider for example that a public coordinator may be more efficient in including public transportation modes in the scheme whereas private transport providers are more willing to work with a private MaaS operator.

The other difference identified in section 6.2. is the different additional features between apps. Two reasons can explain these differences. First, the market in which the MaaS provider is operating has specifics needs and preferences from the users which create specific opportunities for given additional features development or restrains their possibilities on others. Kaulio (1998) emphasizes that customer requirements are a key driver of product and service development processes. Second, MaaS providers around the world may have different capabilities to design and

implement additional successful features which can explain why a given service has different features that others do not possess. Brown and Eisenhardt (1995) identified capabilities that influence the success of product/service development: project team, project leader, senior management, relationship with suppliers and customers, financial success. By having different sets of these capabilities, a given MaaS operator may not encounter the same success in developing a given feature than another one.

The arguments used for explaining the comparison between the existing MaaS schemes and the potential characteristics of a MaaS service in São Paulo call for an adaptation of the concept of MaaS for the Paulista capital city and in general developing countries. Indeed, the existing schemes on which the concept of MaaS has been built in the recent years are all located in developed countries, especially in Europe. The differences in the setup and characteristics of the urban mobility system in São Paulo compared to European cities can interrogate on the assumptions on which the concept relies. For example, the pain points for inter-modal journey planning identified by Kamargianni and Matyas (2017) also apply for São Paulo, but other specific pain points of the city can be considered: over-utilization of public transportation, safety or accessibility of transfers. Such factors also restrain the will of Paulistanos to undertake inter-modal trips and call for adapted features in the MaaS platform to tackle them. Another aspect that call for adaptation can be found in technologies. The technologies that support MaaS schemes in Europe, identified by König et al. (2017), are the ones widely used in Europe in a given period (2010's). Yet, the availability of such technologies, their costs of acquisition and the capabilities of transporters to implement them are uncertain in developing countries. If implemented in developing countries, MaaS may rely on other technologies than the ones used in Europe. Hence the concept of MaaS and in particular the

characteristics of MaaS schemes may be broaden in the future to be more inclusive of the specificities of developing countries.

7. Conclusions

This study aims first at coming up with the potential characteristics of an actionable MaaS platform designed for the urban mobility system of the city of São Paulo. Other objectives are to identify which actors could make part of the core business ecosystem of a MaaS service in São Paulo and define their respective roles, to determine the possible tools enabling the MaaS scheme and explore the advantages of the service for the users in the context of the city.

After providing an in-depth analysis of the urban mobility system in the city of São Paulo with a special focus on inter-modality, we first attempted to evaluate the understanding of mobility actors of the concept of MaaS. The main finding is that their vision often converges towards the academia's definitions especially on three aspects: the shift from a mobility of property of the transportation assets towards a service-based mobility, the increasing role of inter-modality in commuting patterns and the trend towards higher value in transportation services for users.

The study then presents the potential characteristics of a MaaS scheme in the city of São Paulo. (cf. Table 7). The actors to be involved are identified (public transportation, bike-sharing and ride-hailing are the key transporters to be included) and options for coordination (public, private or public and private cooperation) are exposed. The centralization of inter-modal trips payment could build on the Bilhete Único system and integrate debit and credit cards as means of payment, with pay-as-you-go tariff option in the early stage and later subscriptions. The MaaS system can take advantage of the existing technologies in the urban mobility system of the city: mobile app, GPS localization, open data from transport operators, cloud computing. In a further phase, big data

technology for service personalization and mobile ticket validation could also be included in the system. Eventually, the MaaS service can create a strong demand orientation by building on industry practices for customer service and offering opportunities for personalization or customization of the platform (integration of agenda or premium subscriptions). This demand orientation should result on tangible benefits from the users' perspective in terms of gain of time, satisfaction, health and well-being. Eventually, the main interpretation that can be drawn out of these findings is that the conditions are present in the city of São Paulo to kickstart a MaaS project in the short run.

Three limitations to this study can be identified. First, the scope of this study was limited to the city of São Paulo. Yet, it belongs to a wider urban mobility system in the Metropolitan Region of São Paulo (RMSP). Inter-city commuting and their impact on the potential characteristics of the MaaS scheme were not investigated. Since the city of São Paulo is the largest center of the RMSP with most trips and activities and has already more than 10 million inhabitants, it was selected as a sufficient setting at first even if the impact of the rest of the RMSP may marginally affect the findings.

Second, there was an access limitation to some relevant stakeholders in the urban mobility system of the city (ex: Government of the State of São Paulo, some ride-hailing or dock-less bike-sharing companies) due to lack of response. Even if the sample of interviewees was large and diverse to provide good internal validity of the collected data, these players may have enriched the insights of the study.

The last limitation can be found in the sample of interviewees. The scope of the case study, at the scale of one of the world's biggest cities, prevented from interviewing exhaustively all the actors

involved in the mobility system. Hence the set of respondents may be biased since it includes only players who accepted to participate to the study and to whom we had direct or indirect access. In order to limit the impact of this bias, we sought the most diverse sample as possible and to interview several people of similar functions or industry.

To the best of our knowledge, this study is among the first application of the concept of MaaS in the city of São Paulo, but also in Brazil and developing countries. This fact calls for further research on the topic in similar setups, in other cities in Brazil and other developing countries, and to compare the results with the findings of this study. It may also help to refine the concept of MaaS to be more adapted to the specificities of developing countries as evoked in section 6.3. Performing a similar study including a different sample of players in the scope of the entire RMSP can also help evaluate the impact of the inter-city commutes to the potential characteristics of the MaaS scheme. This study collected its data mostly from the supply side of the MaaS ecosystem, hence studying more in depth the demand side would be complementary, in particular to understand the specific needs of commuters in São Paulo with regards to MaaS and define more deeply the benefits of the scheme for the citizen. Eventually, since we provided options for the characteristics of a MaaS scheme in São Paulo, a possible next step would be to create scenarios by choosing a set of characteristics and evaluate their feasibility in the same context.

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Appendix

Appendix 1: Interview protocol (1/2)

Objective	Questions
Presentation	My name is Raphaël Gras, I'm a masters student at FGV. I am currently writing a masters thesis which main theme is urban mobility in São Paulo.
	Do you authorize me to record this interview in order to facilitate data treatment? All data will be anonymized in the final report.
Context	Can you briefly present [transport mode] in São Paulo? *Suggestions: number of daily users, size of fleet, geographical presence, function, responsibilities*
	Have you ever heard about the concept of MaaS platforms? If you have, how would you quickly define them?
	The formal definition of a MaaS platform is a "Multimodal and sustainable mobility service addressing customers' transport needs by integrating planning and payment on a one-stop-shop principle". From a user's perspective, MaaS is a single interface on which the client plans an intermodal journey, pays and gets tickets for all the modes they are going to use, and follows the progression of the trip in real-time
	How would you picture a MaaS platform in SP?
Transport modes and related services	Do you consider [transport mode] compatible with other transport modes in São Paulo? How does [transport mode] integrate with other transport modes in SP?
	Are there previous iniatives to promote multimodality including [transport modes]? What have been the main challenges? What results were achieved?
Platform	How do the users currently access information about the service? How do they access the service?
	Is there any digital platform that give access to the service? If yes, what are the main functionalities featured?
	What was the motivation for choosing this customer interface rather than another one?
	What are the strengths and weaknesses of this interface?
Use of technology	What ICT currently power your service (and digital platform)? *Suggestions: GPS, IoT, Database Management Systems, E-Payment, E-ticketing, etc.*
	What was the motivations for choosing these technologies?
Available functionalities	Is your service integrated with journey planner like Google Maps, City mapper, Moovit, etc.? How does this integration is realized technically? Is such an integration replicable (or feasible) in the future with other journey planners? What have been the benefits of integrating with journey planners? Difficulties?
	How do your users currently book trips with your service and get tickets?
	How do your users currently pay trips with your service? Challenges with cashless payment? Demands from consumers for new methods *(Ggl/Apple pay?)*
	How do your users currently receive invoices? Could invoicing be digitized?
	How do your currently provide customer service? Strengths and weaknesses of this method?

Appendix 2: Interview protocol (2/2)

Objective	Questions
Customization	Can the user customize purposely some features of your service?
	What benefits for Maxi and for the clients do you get out of this customization?
	What are the main challenges related to customization?
Registration requirement	Do you require your user to register before they use the service? Why?
	What minimum information do you need from your users to be able to provide them with your service?
	Have any challenges arisen from registration requirements?
Personalization	Can you currently personalize your service to the user? How?
	What information would you require from your users to be able to personalize they experience?
	What benefits for [transport mode] and for the clients do you get out of this personalization?
	What are the main challenges related to customization?
Tariff option	What tariff options do you currently offer to your users?
	Could you offer new tariff options in the future (ex: subscription, pay-as-you-go)
	Would you be open to integrate your tariff with multimodal packages?
Multiple actors	By definition, MaaS platforms join several actors (private and public) to build an innovative service. What kind of organization to you think would enable efficient cooperation between public and private transport providers (SP Trans, Metrô, ... / Uber, 99, bikes)?
	What would be the main challenges when building such an organization from your point of view?
	Who do you think should be the coordinator of such an organization? Why? (Why not the other option?)
Demand orientation	Do you think a higher integration of [transport mode] with other transport modes would be beneficial to [transport mode] users' satisfaction?
	How do you ensure that you offer the best quality of service as possible to your clients?
	What mechanisms are used to monitor the quality of service?