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TOWARDS SUSTAINABLE MOBILITY-AS-A-SERVICE: A ROADMAP FOR SAN LUIS POTOSÍ, MX, USING THE MAAS READINESS INDEX

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Abbreviations

API	Application Programming Interface
BRT	Bus Rapid Transit
CONAPO	Consejo Nacional de Población (National Population Council)
CONEVAL	Consejo Nacional de Evaluación de la Política de Desarrollo Social (National Evaluation Council for Social Development Policies)
DCMI	Deloitte City Mobility Index
EU	European Union
GDP	Gross Domestic Product
ICT	Information and Communication Technology
INEGI	Instituto Nacional de Estadística y Geografía (National Institute of Statistics and Geography)
IOM	Index of Openness for MaaS
ITDP	Institute for Transportation and Development Policy
MaaS	Mobility as a Service
MM	Mixed-Methods
MMI	MaaS Maturity Index
MRI	MaaS Readiness Index
MRLI	MaaS Readiness Level Indicators for local authorities
MX	Mexico
NMS	New Mobility Services
NUA	*New Urban Agenda*
PIMUS	Plan Integral de Movilidad Urbana Sustentable (Integrated Plan of Sustainable Urban Mobility)
PPP	Public-Private-Partnership
PT	Public Transport

QCA	Qualitative Content Analysis
QDA	Qualitative Data Analysis
SCT	Secretaría de Comunicaciones y Transporte (Secretariat of Communications and Transport)
SDG	Sustainable Development Goal
SIMBAD	Sistema Estatal y Municipal de Bases de Datos (State and Municipal System of Data Bases)
SLP	San Luis Potosí
SUMP	Sustainable Urban Mobility Plan
TDM	Transportation Demand Management
TOD	Transit-Oriented Development
UCL	University College London
UITP	L'Union Internationale des Transports Publics (International Association of Public Transport)
UK	United Kingdom
UMII	Urban Mobility innovation index
UN	United Nations

Abstract

Mobility-as-a-Service (MaaS) describes a concept that aims to integrate the fragmented tools and services a person needs to conduct a trip. The integration allows customers to access and combine the variety of services based on their individual needs. Given this fact, it represents a possible alternative to personally-owned modes of transportation.

The present investigation focusses on the applicability of MaaS on the case city of San Luis Potosí in Mexico. It seeks to analyse whether the city is prepared for Mobility-as-a-Service. For this purpose, the modified MaaS Readiness Index (MRI) has been introduced as an assessment tool. Besides, a supplementary roadmap towards sustainable MaaS was developed.

This study uses a mixed methods approach that applies for all stages of the investigation. A variety of tools, such as expert interviews, surveys, and a literature review came to use for the data acquisition. The assessment of the MaaS readiness grounds on preparatory qualitative and quantitative data analysis steps that were required for a subsequent scoring workshop. The roadmap creation on the other hand builds upon the outcomes of the MRI assessment and a qualitative content analysis.

The findings indicate that San Luis Potosí has “some usefulness for MaaS, but below what would be desirable”. In particular, the regulatory environment was evaluated as highly unfavourable. The sustainable MaaS roadmap targets principally on the improvement of weak spots with a strong systemic effect.

Keywords: Mobility-as-a-Service, MaaS readiness, MaaS roadmap, Integrated mobility planning

Contents

1 Introduction

Urban mobility is increasingly witnessing the impacts of trends, such as urbanisation, sociocultural shifts or digitisation (Rode, & Hoffmann, 2017). Especially the pattern of urban sprawling, which is impelled by the increase in population, has created settlements that are difficult to be served by public transportation. Thus, this phenomenon has fostered the dominance of car mobility (for the wealthier) or lack of access (for the poor) (UNITAR, 2012). Latin-American cities are among the most affected from this development (UNITAR, 2012). This applies in particular for the 51 metropolitan areas with over one million inhabitants. Between 1950 and 2010 the urbanisation rate grew from 40 to 80%, and the forecast indicates a rate of 90% for 2050 (Mojica, et al., 2015). Currently, there are 470 million people living in urban areas of Latin-America. "Different from developed countries, where urbanisation has historically occurred gradually, major cities in this region have experienced explosive growth in recent decades" (Mojica, et al, 2015).

This research project examines the case of San Luis Potosí in Mexico, which suffers from a variety of implications that are typical for Latin-American metropolises. López Pérez (2017) argues that the rapidly increasing motorisation rate combined with a weakly developed infrastructure are among the primary causes of a series of environmental, social and economic problems. In order to enable more sustainable urban development, as well as travel behaviours, the integration of transport services is viewed as a necessary precondition (Szyliowicz, 2003). With regard to the latter and to the several consequences the case city is facing, this investigation seeks to deliver a guideline for an integration of services that will foster seamless multimodality. The approach is thereby grounded on the newly emerging concept of Mobility-as-a-Service (MaaS). MaaS describes the "aggregation of end-to-end journey planning, booking, electronic ticketing and payment services across all modes of transportation, public or private, in one digital platform" (Goodall, et al., 2017). This provision of "shared" resources over a technological platform complements peoples' increasing tendency to embrace access over ownership (Tyson, 2016). This manifests also in the rise of mobile-device-based mobility services, such as carsharing, bikesharing or ridehailing.

The focus of the present research lies on the evaluation of San Luis Potosí's current readiness for Mobility-as-a-Service and to propose a sustainability envisioning MaaS strategy. The study phases can be resumed into the three following research questions:

(1) *What is the current situation of urban mobility in San Luis Potosí?*
(2) *In how far is San Luis Potosí prepared for Mobility-as-a-Service?*
(3) *What elements are to be included in a roadmap towards Sustainable Mobility-as-a-Service for San Luis Potosí?*

This document is structured in six chapters. Chapter one gives a brief introduction to the topic as well as to the problem statement and why it needs to be addressed. In addition, the research questions are described here. The second chapter is regarding the theoretical and conceptual framework. Therefore, the discourse around the subject is being depicted, such as the impacts of megatrends on urban mobility or sustainable urban planning approaches. Furthermore, it contains broad information about the Mobility-as-a-Service concept and an outline of the research design. Chapter three portrays the methodology of this investigation. This involves detailed descriptions of data requirements, data acquisition and data analysis. The fourth chapter represents a characterisation of the case city San Luis Potosí. In chapter five the assessment results and the roadmap are being presented and discussed. Chapter six summarises and concludes the research. This includes also an outlook and recommendations for future investigation needs.

2 Theoretical and conceptual framework

2.1 Megatrends and their implications for urban mobility

Megatrends are reshaping the way people live and move in an increasingly globalised world (Delle Site et al., 2012). They represent unprecedented shifts that can result in opportunities and obstacles (Hoppe et al., 2014). A thorough understanding of these forces are an important key to enable a more sustainable environment, especially regarding tomorrow's societies' urban travel patterns. According to Tyson (2016), there are four principal megatrends that work together in transforming urban mobility. These are shown in Table 1 in a summarised form and subsequently described in detail.

Table 1. Megatrends affecting urban mobility.

Megatrends	**Urbanisation**	**Climate Change and Sustainability**	**Sociocultural shift**	**Technological development**
Subtrends	Congestion Demand for new infrastructure Air quality Changing markets and habits	Air quality Resource depletion Greater focus on resilience	Millennials Ageing population Population growth	User-centred mobility Integrated and intelligent transport Digitisation of tickets and payments Automation Constant public and private innovation
Implications	Pressure on transport networks Investment requirement Regulation to limit pollution	Fuel efficiency Multiple Energy sources Regulation to limit pollution and/or incentivise new technology Changed behaviours	More pressure on transport capacity Risk of isolation, lack of access to mobility Access over ownership	Development of innovative new services and products New business models Technology as part of environmental protection

The earth is undergoing the largest wave of **urbanisation** in its history. In 2007, UN population figures indicated that for the first time more than half of the world's population lived in cities. That proportion is set to rise to 67% by 2050 (Van Audenhove et al., 2014). The high concentration of people in urban environments is accompanied by a massive growth in individual journeys, particularly regarding cities of the global south. Currently, 64% of all travelled kilometres are accounted to urban areas which sum up to 25.8 trillion km. A number that is expected to treble by 2050 (Van Audenhove et al., 2014). This estimate is in line with the general tendency towards urban sprawl, or as Duhau López (2008) refers to this phenomenon –

the creation of insular cities. It describes settlement patches that are only loosely linked to a nuclear urban space, most commonly by a sole collector highway. Dwellers increasingly move to these peripheral areas to avoid high housing costs in the centre, but at the same time they distance themselves from general public services or their working places (Medina Ramírez et al., 2012). This emerging isolation of the habitat is difficult to be served by public transportation and services. As a consequence, it fosters the dominance of car mobility for the wealthier or lack of access for the poor (UNITAR, 2012). Litman (2017) states that many conventional transport and urban planning practices are additionally contributing to the creation of a cycle of automobile dependency (see figure 1). Van Audenhove et al. (2014) indicate that this problematic will further intensify as many people entering the global middle class will choose to use private motorised transport. Consequently, increments in atmospheric contamination, pressure on transport networks and other implications are to be expected (Mojica et al., 2015). This development has profound impacts on various dimensions. For instance, gridlocks are already causing an economic loss of $200 billion, or nearly 1% of the GDP across Germany, Britain, France and the US (CEBR & INRIX, 2014). That figure is expected to rise to nearly $300 billion by 2030 and highlights the need for massive investments in alternative mobility solutions in order to cope with the increasing demand (Van Audenhove, et al. 2014).

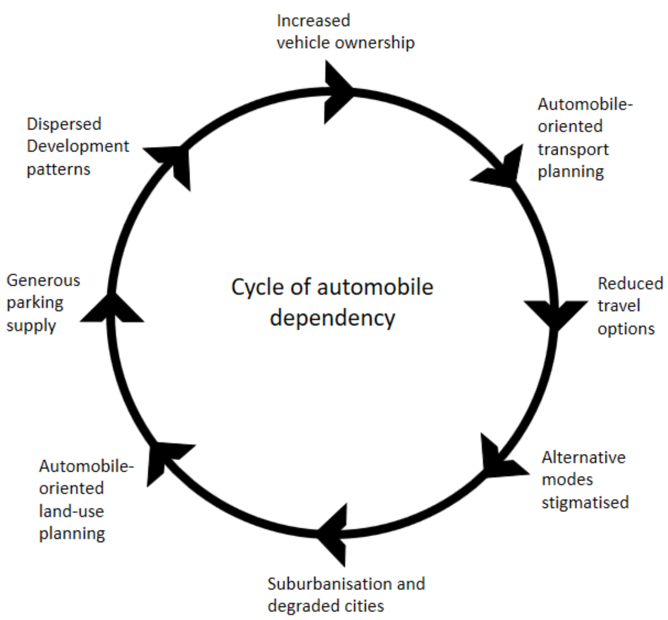


Figure 1. Cycle of automobile dependency (Litman, 2017).

Climate change is an unprecedented challenge, affecting every aspect of life on earth. Cities are in the centre of this crisis as they consume 80% of the global material and energy supply and are responsible for 75% of carbon emissions (Peter, & Swilling, 2012). Particularly, the transport-related greenhouse gas emissions show no signs of slowing down. They are expected to be 30% higher in 2025 compared to 2005 levels (Van Audenhove, et al., 2014). Boundless growth strategies that regard resources as inexhaustible have become untenable (Peter, & Swilling, 2012). The omnipresent implications through climate change have led to a greater focus on **sustainability and resilience** and "unleashed an explosion of scientific research" (Bettencourt & Kaur, 2011). These efforts converged into the formulation of the Sustainable Development Goals (SDGs), the lighthouse initiative of the United Nations (September/2015). As one among many aspects, the need for reductions of transportation impacts, particularly from and on cities, has been emphasised in the SDGs. They are encompassing accessibility considerations, road safety, air pollution, sustainable infrastructure and other issues. Target 11.2 of the document *Transforming our world – The 2030 Agenda for Sustainable Development* (United Nations, September/2015) says:

> *"By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons."*

It is the most direct target for the urban mobility sector, but yet not the only one. Figure 2 shows all SDGs that are directly or indirectly linked to transportation. The Sustainable Development Goals were also taken as baseline for the formulation of the New Urban Agenda (NUA). The NUA is the outcome document of the Habitat III conference in Quito, Ecuador, In October 2016. This agenda is guiding efforts for urban policies and approaches for the next 20 years (UN Habitat, 2016).

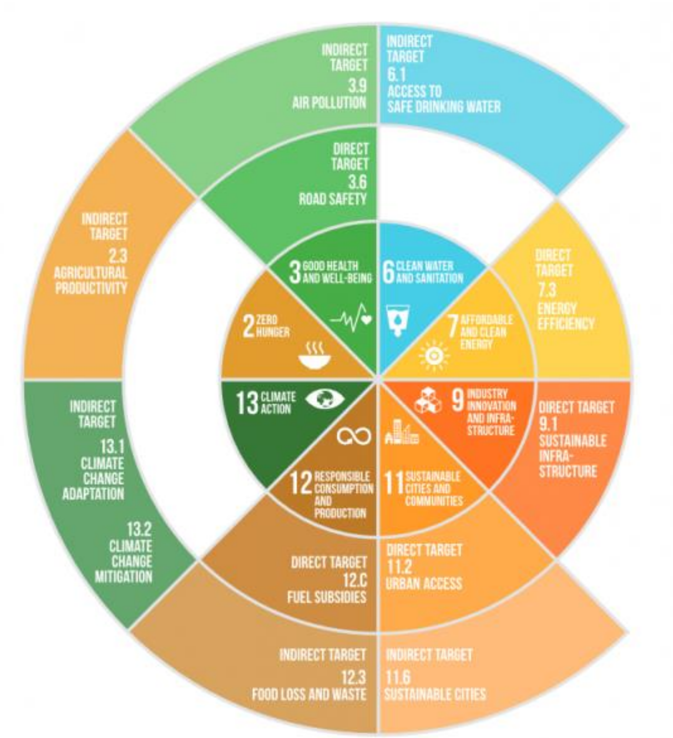


Figure 2. Transport-related SDGs (SLoCaT, 2017).

Currently, a variety of **sociocultural shifts** can be observed that affect the mobility of urban areas. They range from demographic trends, such as the general increase in population or an ageing society, up to peoples' constantly changing preferences (Tyson, 2016). This includes their residential and working preferences as well as other factors, such as high transportation costs, new mobility alternatives, technological development, etc. All these internal and external factors have a combined effect on individual travel behaviour (see figure 3, Giesecke, Surakka, & Hakonen, 2016, ERTRAC, February/2017). Despite the prevailing linear trend towards private motorised transport (Mojica et al., 2015), especially young people tend to choose active transport options (Davis, Dutzik, & Baxandall, 2012). Goodall et al. (2015) state that 55% of 1.045 surveyed millennials (18-34 years old) in the US make an effort to drive less, which manifests also in lower car ownership rates. The identified key reasons are the high costs that are associated with car ownership but also an increasing environmental awareness (Goodall et al., 2015). According to Axhausen (2013), millennials are less likely to obtain a driver's license. Tyson (2016) noted an emerging zeitgeist that embraces access over ownership, mostly through the provision of shared resources over technological platforms. A report about the impacts from millennials' behaviours by Euromonitor International (October/2015), agrees with the previous characteristics. Nonetheless, they suggest to differentiate between millennials from developed economies and those from emerging countries. While western millennials have been more focussed on temporally access, emerging millennials continue to value higher the ownership and exclusivity of goods. This is due to the reason that the required environment for digital solutions is not as progressive as in developed countries but also because of the urge to possess what previous generations did not (Euromonitor International, October/2015). In recent years though, urban millennials in emerging countries have begun to mimic their counterparts from

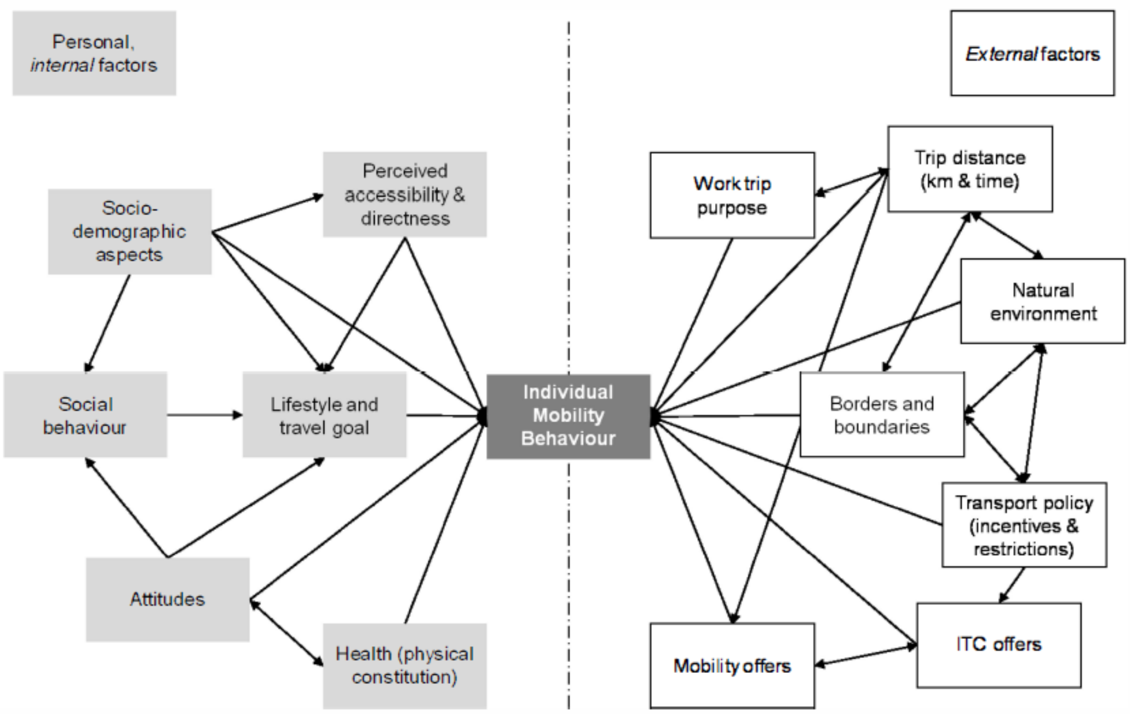


Figure 3. Factors influencing individual mobility behaviour (Giesecke, Surakka, & Hakonen, 2016).

developed economies. It appears that the consumption model of "popular in the West, becomes popular for the rest" is generally true, at least considering sociocultural changes driven by digitisation (Euromonitor International, October/2015). Rode and Hoffmann (2015) state that millennials' attitudes and their role as digital natives have already and will further diversify the individual travel behaviours. The authors distinguish between six mobility pattern groups which are characterised through different perspectives towards travel, the environment, technology and residential preferences (see table 2).

Table 2. Mobility attitude groups (Rode, & Hoffmann, 2015). In particular, the mobility attitude groups five and six are composed of millennials.

Attitude group	Characteristics
(1) Traditional car-oriented	This group rates driving highly. Digital technology is not valued and alternative modes are rejected as impractical or uncomfortable. Further characteristics: • Medium to higher ages and medium to higher incomes • Highest car and home ownership rate • Car is main mode with highest annual vehicle kilometres • Not amenable to new transport and mobility services (electric car, travel apps, etc.)
(2) Pragmatic transit sceptics	While this group rates driving highly, it expresses diverse attitudes towards the use of other modes. Technology is disliked and travel habits tend to reflect a pragmatic orientation emphasising convenience and individual travel. Further characteristics: • Higher ages and lower incomes • High car ownership rate • Car and public transport are main modes • Modestly amenable to using electric cars; not amenable to other services
(3) Green travel oriented	This group is environmentally conscious and prefers modes of transport that are understood to be more sustainable. While this may include innovative use of alternatives, technology is not widely appreciated. Further characteristics: • Medium to higher ages and lower incomes • Low car ownership rate • Low car use, higher share of walking • Responsive to social norms in travel choice, but not amenable to electric cars or other travel services
(4) Pragmatic transit-oriented	This group rates various aspects of public transport positively, but not necessarily for environmental reasons. There is some modest dislike of digital technology. Further characteristics: • Medium ages and lower to medium incomes • Low car ownership rate • Low car use and highest use of public transport • Modestly amenable to using travel apps
(5) Technology focused individualists	This group values autonomy highly, and enjoy driving, cycling and using digital technology to reinforce independence. Further characteristics: • Younger with higher incomes • Higher car ownership rate • Car and public transport main modes • Amenable to using electric cars and digital travel services
(6) Innovative access-oriented	This group is well aware of transport alternatives and use digital technology to support innovative travel choices. They have a strong desire to live centrally. Further characteristics: • Younger with higher incomes • Lower car ownership rate • Public transport as main mode as well as car and cycling • Strongly amenable to new travel modes and services

Apart from the recent dynamics in individual behaviours, there has been also an ongoing development in private and public business culture. This reaches from an increased importance of corporate social responsibility, to the creation of Public-Private-Partnerships and open data policies in order to intensify cross-sectoral collaboration (Grisby, 2016).

The **technological development and penetration** of the internet, the smartphone and connected devices are regarded as the motor of innovation. They can provide "access to more travel options and real-time status than the control rooms of any operator" (Goodall et al., March/2015). Information and Communication Technologies (ICT) are the linking element to unlock other technologies' potential (Meyer, & Shaheen, 2017). According to Goodall et al. (March/2015), this megatrend is being accompanied by five sub-currents which are described as follows:

- User-centred mobility services
- Integrated and intelligent transport networks that respond in real-time
- Digitisation of tickets and payments
- Automation
- Constant public and private innovation to meet customer's unstated or future needs

The combined effects of these trends foster the development of innovative services and products as well as new business models. Beside the important role as business facilitator, the Ericsson Mobility Report (November/2015) highlights also that technological development will become a crucial complement towards environmental protection and improvement of public health. It is estimated that ICT applications could enable 15% reduction in greenhouse gas emissions by 2030. Despite the high risk potential that results from megatrends, they can also enable many opportunities, such as the encouragement to adopt more sustainable mobility schemes (Hoppe et al., 2014). Figure 4 shows that particularly since the turn of the millennium mobility alternatives have experienced a wide distribution. Van Audenhove et al. (2014) are expecting that over the next decade smartphone-based mobility options, both via peer-to-peer and operator-to-customer models, will become more popular. This includes **sharing economy models**, such as car- and bikesharing, carpooling and ridehailing, among many others. These new mobility services (NMS) are in the centre of the debate about *access over ownership.* Especially in the largest and densest cities, as well as, to a lesser extent, in smaller urban areas NMS are being increasingly used in complement to conventional transport modes. Sprawling and sparsely populated areas on the contrary, are less appropriate for these models (Center for

Automotive Research, 2016). The rise of shared mobility services is related to different trends that exert various pull and push forces. The most important enablers are digitisation, automation, the trend towards app-based payments and changed mobility preferences. Pushing forces are for instance the increased congestion, constraints on resources as well as ownership costs (Center for Automotive Research, 2016). Grisby (2016) identified, that "the more people use shared modes, the more likely they are to use public transit, own fewer cars, and spend less on transportation overall". Although the expansion of shared mobility solutions has increased immensely, van Audenhove et al. (2014) states that the full potential has not been unleashed yet. Mostly, due to the reason that the urban environment is too fragmented and thus hostile to innovation. But also because of the uncertain long-term impacts of sharing economy models. In accordance with this statement, McKerracher et al. (2016) anticipate risks for the current revenue models and eventual social exclusion but note equally the potential for socio-environmental improvements and new revenue opportunities. They affirm that the implementation of new mobility services could improve the local access to mobility by enabling new travel options across the population from different generations and income-segments.

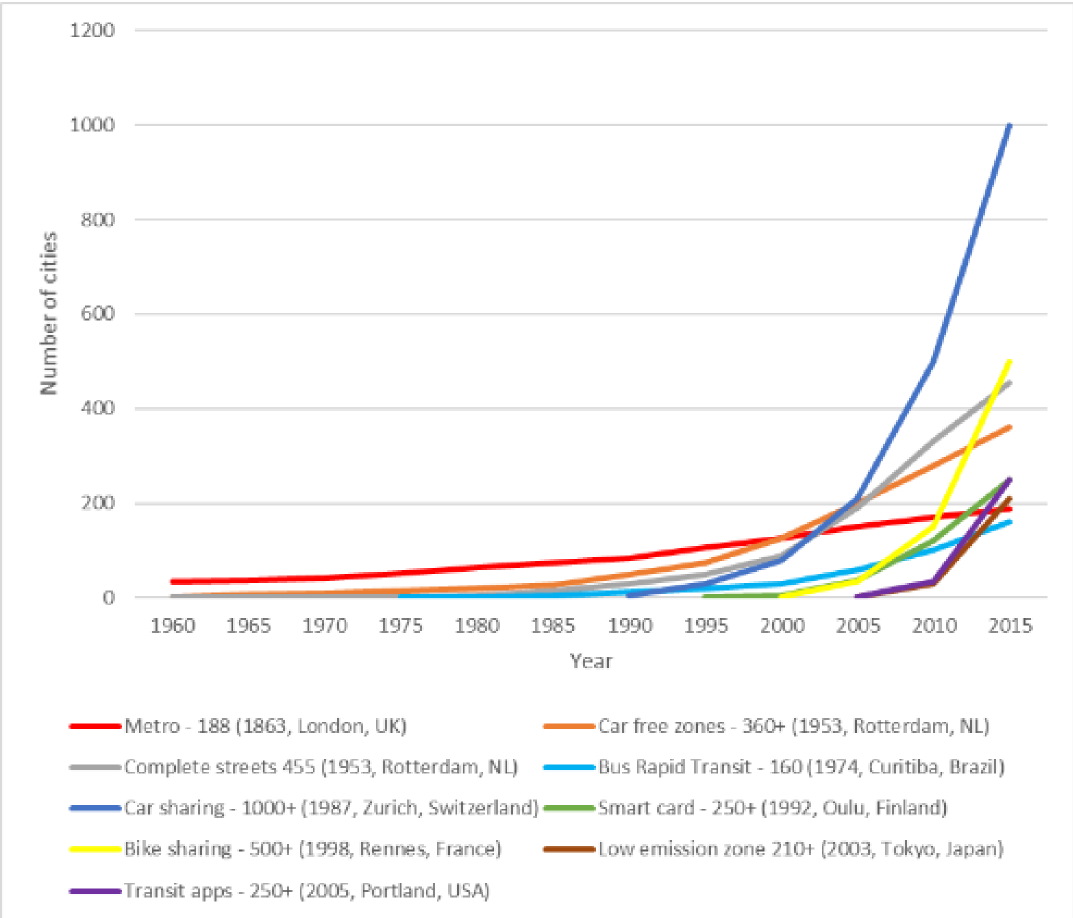


Figure 4. Rate of adoption of sustainable transport schemes across the world (in brackets is the first major example of each) (Burrows, Bradburn, & Cohen, 2017).

Disruptive technologies occupy a special status inside the trend of technological development. They have the potential to substitute existing solutions while creating new markets and transforming society (Meyer, & Shaheen, 2017). For instance, the revolutionary invention of the automobile only became disruptive when the assembly line manufacturing emerged which converted the car into an accessible mass product. The result was the complete or near replacement of carriage and animal transports as well as a profound sociocultural change. Today, none of the intensively discussed revolutions, such as car- or bikesharing, electric vehicles or autonomous driving alone have the potential to disrupt prevalent mobility patterns (Meyer, & Shaheen, 2017). All of them are facing various financial, legal and cultural obstacles to allow for a mass implementation. Nevertheless, if combined among each other real synergy effects could arise that would make travel cheaper, cleaner, and more accessible, particularly in cities (Meyer, & Shaheen, 2017).

2.2 Sustainable urban mobility planning

Urban planning and travel behaviour are two reciprocal elements that are constantly evolving over time (ERTRAC, February/2017). Figure 5 visualises this development and the associated paradigm shift in a schematic form (Copenhagenize, 2013). It appears that before the mid-20th century, especially active transport modes were highly prioritised in the management of the urban environment. After that though, the mass implementation of private cars disrupted peoples' mobility behaviour as well as the way how cities were planned (Meyer, & Shaheen, 2017). Already in 1933, Le Corbusier published the Athens charter that fostered the creation of functionally divided and automotive cities with broad connector highways. In particular, civil society organisations used to criticise the infrastructure development as further demand generation, true to the expression, "those who sow streets, shall reap traffic" (Verron, et al., December/2005). For a long time, such effects were denied by "respectable transportation

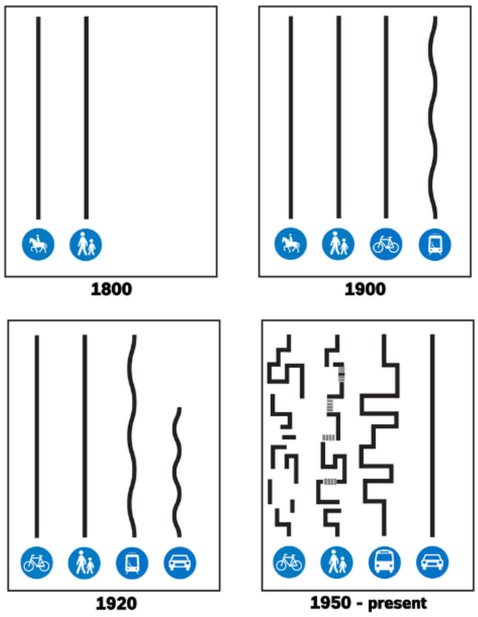


Figure 5. A short history of urban planning (Copenhagenize, 2013).

science” (Verron, et al., December/2005). However, in the meantime, a number of scientific investigations have proven unambiguously the existing correlation (Litman, & Coleman, 2001, Speck, 2013). In response to this and other related socio-environmental implications, novel planning approaches are being developed that target the still prevailing car-centred paradigm in cities around the world. The Sustainable Urban Transport Project (GIZ, 2017) resumes those efforts into ten principles:

(1) Planning dense and human scale cities
(2) Optimising the road network and its use
(3) Developing transit-oriented cities
(4) Encouraging walking and cycling
(5) Implementing transit improvements
(6) Controlling vehicle use
(7) Managing parking
(8) Promoting clean vehicles
(9) Communicating solutions
(10) Approaching the challenges comprehensively

In the following, a selection of leading approaches that seek to apply a variety of the before mentioned principles are shortly being outlined. This includes for instance the concept of the “walkable city” by Jeff Speck (2013) as well as the “Copenhagenize project” (focus on cycling) which was strongly influenced by Jan Gehl’s “human scale” planning practices (Gehl, 2010). Both initiatives aim to make cities more accessible to active transport modes and less car-dependent through interventions in urban design and policies. The transit-oriented development (TOD) represents a strategy that seeks to offer the maximum amount of mixed land uses (residential, business, leisure, etc.) within walking distance of public transport (Dittmar, & Ohland, 2004). A successful TOD depends highly from an optimally routed public transport network. Todd Litman (2012) proposes to use transportation demand management (TDM) measures. They describe a set of practices and policies to reduce travel demand, or to redistribute this demand in time or space. The implementation of new mobility schemes, such as Bus-Rapid-Transit (BRT) or shared economy options, can also be regarded as part of sustainability improvements. However, many examples around the globe have shown that they are often being implemented “in-silo” which inhibits the unleashing of their full potential (Kamargianni, et al., 2018).

The International Association of Public Transport (UITP, April/2016) concludes, that the key to effectively challenge the flexibility and convenience of the private car, is to achieve the integration of multiple transportation means and services. The backbone has to be an efficient public transport as well as the facilitation of active mobility (UITP, April/2016). Integrated transport modes complement and reinforce each other while creating multimodal connectivity (Kuwahara et al., April/2016). Szyliowicz (2003) claims that integration is a necessary precondition for sustainable mobility. According to him, an integrated mobility system "has to offer choices, efficient conditions, coordination between modes, and cooperation between government agencies at all levels and the private sector" (Szyliowicz, 2003). The term "transformation of urban mobility" is often used in this context. It describes a process in which decision makers are aware of the mobility dynamics and can thus shape the development actively (Hoppe et al., 2014). Therefore, individualised sustainable urban mobility plans (SUMP) are being formulated according to the specific needs of a city (Wefering, et al., 2013). SUMP's converge various elements of different planning approaches, in order to improve the internal accessibility of urban areas and provide sustainable mobility options (Wefering, et al., 2013). The integration of existent and novel transport modes is usually the centrepiece of SUMP's, due to its high importance for sustainability. Poliaková (2013) states, that integration has to occur on three different levels. These are:

(1) *Transport integration* – coordination and optimisation of timetables and line tracing between the transport operator, mobility services and the customer demand
(2) *Organisational-economic integration* – development plans; multi-stakeholder agreements (e.g. PPP); combined information system; controlling; etc.
(3) *Tariff integration* – creation of comprehensible tariff system; tickets that allow changing transport modes; etc.

The ongoing development of technologies has enabled various opportunities for an even broader integration of transport modes (Mojica, et al., 2015). In 1992, the first example of payment integration in form of a smartcard was implemented in Oulu, Finland (Burrows, Bradburn, & Cohen, 2017). Although the use of smartcards is still increasing, integrated mobility platforms based on mobile devices are rapidly gaining traction (Van Audenhove, et al., 2014). This has extended the debate to the combination of multimodal trip planning services, integrated real-time information systems, tracking of vehicle locations, reservations and bookings, etc. across all transport operators and mobility providers (Mojica, et al., 2015).

Currently, the broadest spectrum of mobility integration is being offered by Mobility-as-a-Service (MaaS), which is going to be described in the following chapter.

2.3 Mobility-as-a-Service

Mobility-as-a-Service is the most recent innovation in the sector of integrated mobility planning and firmly grounded in the idea of access over ownership (Hietanen, 2014, Matyas, & Kamargianni, 2017). It differs significantly from other mobility services because they are usually not or only insufficiently linked with alternative modes of transportation (Kamargianni, & Matyas, 2017). MaaS instead, aims to close the gap between fragmented means and services of public and private transport operators that are needed to conduct a trip (Hietanen, 2014).

Since the coining of the term "Mobility-as-a-Service" in 2014 by Heikkilä, its understanding has significantly evolved (Holmberg, et al., 2016). Jittrapirom et al. (2017) state, that MaaS "can be thought of as a concept (a new idea for conceiving mobility), a phenomenon (occurring with the emergence of new behaviours and technologies) or as a new transport solution (which merges the different available transport modes and mobility services)". The research is still far from maturity which manifests in a lack of a precise definition and clear conceptual framework. Various authors, think-tanks and organisations, such as Heikkilä (2014), Holmberg et al. (2016), Eckhardt et al. (2016) and Catapult Transport Systems (2016), have made important contributions to a general definition of Mobility-as-a-Service. The majority strongly emphasises the essential user-centric vision of MaaS which frames the mobility service provision (Jittrapirom, et al., 2017). However, there is a certain disagreement among most streams around which transport modes and mobility providers the development shall occur. For instance, Gould, Wehrmeyer and Leach (2015), envision MaaS as an opportunity to foster the diffusion of electric vehicles to decarbonise transport. Giesecke, Surakka and Hakonen (2016) highlight that the already operational MaaS system "Tuup" in Turku, Finland, concentrates almost exclusively on corporate customers and shared mobility services. The UITP (2016) on the other hand claims that MaaS needs to consider the whole spectrum of users and has to be developed around public transportation. Although most interpretations include indirect sustainability aspects, Holmberg et al. (2016) as well as Giesecke, Surakka and Hakonen (2016) are among the few authors who underscore the crucial importance of MaaS as contribution to the sustainability vision. Hietanen (2016) additionally states that the balance of the triad economic, ecologic and social development has to be the key value driver for a sustainable MaaS. A literature review conducted by Jittrapirom et al. (2017) resumed the different Mobility-as-a-Service approaches into nine core characteristics:

(1) *Integration of transport modes and mobility services* (encourage use of public transportation by facilitating multimodal connectivity; strong focus on sustainability)
(2) *Tariff options* (e.g. pay-as-you-go or monthly mobility packages)
(3) *One digital platform* (one-stop-shop principle via mobile app or webpage)
(4) *Multiple actors* (suppliers of transport and mobility services: e.g. public and private; demanders of mobility: e.g. private or business customers)
(5) *Service aggregator* (e.g. third party, PT provider, authority; one or multiple co-existing aggregators)
(6) *Use of technologies* (mobile devices, mobile internet network, GPS, e-ticketing and e-payment systems, etc.)
(7) *Demand orientation* (multimodal trip planning and traveller information in real time)
(8) *Registration requirement* (subscription to access individual mobility account)
(9) *Personalisation and customisation* (considers individual preferences: time, sustainability, price, special needs and constraints, e.g., disability, child seat, etc.; possibility for special offers and frequent customer programs)

A very comprehensible definition that condenses some of the most essential aspects of the latest discourse was phrased by Matyas and Kamargianni (2017). Since the original definition does not include the critical aspect of sustainability it has been additionally included:

> "*Mobility as a Service is a user-centric, intelligent mobility distribution model in which all mobility service providers' offerings are aggregated by a sole [sustainability envisioning] mobility provider, the MaaS provider, and supplied to users through a single digital platform."*

One central element of the before mentioned definition is the MaaS provider (also operator, aggregator or integrator) who is being introduced as a new player to the transportation market (Kamargianni, & Matyas, 2017). The MaaS provider operates as an intermediary who lowers or ideally removes the barriers that are related to travelling and to interlinking with other actors in order to facilitate the travel experience for users (Kamargianni, & Matyas, 2017, see figure 6). Different stakeholders can potentially operate as integrator, such as the local authority, the public transport provider or a third party business. According to Hietanen (2016), it is also imaginable that various MaaS operators might co-exist in one area. Table 3 shows a review of existent MaaS business models with different types of integrators.

*Table 3. Review of MaaS schemes (Jittrapirom, et al., 2017) (Note: *Planned service).*

Platform (area)	**Optymod (Lyon, France)**	**SHIFT (Las Vegas, USA)**	**Mobility shop (Hannover, Germany)**	**Tuup (Turku region, Finland)**	**Whim (Helsinki, Finland)**	**WienMobil (Vienna, Austria)**
Status (year)	Operational (2012-present)	Shut down (2013-2015)	Operational (2014-present)	Operational (2015-present)	Operational (2016-present)	Based on “Smile” pilot (2014-2015), Operational (2015-present)
Transport modes and related services	PT Bike sharing Regional train Parking	Bike sharing Car sharing Taxi Shared shuttle	PT Car sharing Taxi Regional trains	PT Bike sharing Car sharing Car rental P2P car rent Taxi and shared taxi Parking rent Freight service*	PT Rental car Taxi Regional rail Bike sharing* Car sharing*	PT Bike sharing Car sharing Taxi Parking garages
Tariff option	None	Monthly tariff	Fixed monthly membership to access discounted tariff	Pay-per-use	Three monthly packages and pay-per-use	Pay-per-use
Platform	App	App	App	App	App	App
Available functionalities	Real time info. Congestion prediction Trip planning Booking (bike sharing) Service alerts Plane’s arrival and depart. time	Trip planning Booking Payment Invoicing	Real time info. Booking Ticketing Payment Invoicing 24hr customer service phone line	Real time info. Trip planning Booking Ticketing Payment (for PT, taxi and shared taxi)	Real time info. Trip planning Booking Ticketing Payment Invoicing	Real time info. Trip planning Booking Payment Invoicing
Type of actors involved	Public actors	Private actor	Public and private actors	Public and private actors	Public and private actors	Public and private actors
Service aggregator	Local authority	Third party	PT provider	Third party	Third party	PT provider
Use of technologies	GPS	GPS / ePay	GPS / ePay / Smartcard	GPS / ePay (PayIQ)	GPS / ePay	GPS / ePay
Demand orientation	Yes	Yes	Yes	Yes	Yes	Yes
Registration requirement	Yes, for customisation	NA	Yes, for usage and customisation	Yes, for usage and customisation	Yes, for usage and customisation	Yes, for booking and customisation
Personalisation and customisation	Input personal address, preferable modes and ownership of bicycle; Select service subscriptions for notifications	Automatically optimised trip planner; Mobility budget with top-up	Store favourite trips and recall previous trip; Possibility to create individual mix of transportation; Booking and payment cancelation	Optimised travel plan based on user’s daily agenda; Preferred modes, based on cost and CO_2 footprint	Calendar synchronisation and personal info sharing; Social interaction; Cancellation; Change of subscription	Save personal mobility profile; Store car and bike sharing membership; Preferred modes, based on cost, time and CO_2 footprint

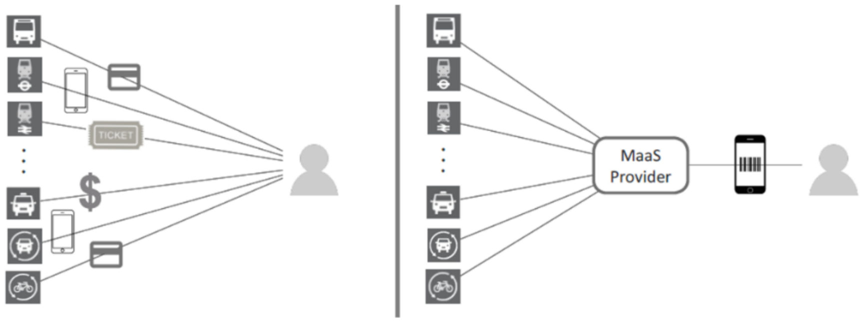


Figure 6. The MaaS provider as aggregator of services (Matyas, & Kamargianni, 2017).

Whether MaaS will ultimately foster a more sustainable development depends highly on how the market will evolve locally, which actor will represent the MaaS provider and which services and transport means are going to be prioritised (Hoadley, 2017). The vast majority of authors (Dotter, August/2017, Matyas, & Kamargianni, 2017, Catapult, 2017) highlight the potential benefits of MaaS for customers, environment, public sector and businesses while possible negative implications are regarded only seldom. Hoadley (2017) as well as Smith, Sochor and Karlsson (2017) for instance, emphasise the risks of a purely commercial approach to Mobility-as-a-Service. They observed a great disruptive potential of MaaS for public transport services and policies. Meyer and Shaheen (2017) claim that the ongoing increase in integration will further stimulate disruption on various dimensions, leaving unstated whether this change will lead to more benefits or drawbacks. According to Li and Voege (2017), Mobility-as-a-Service "holds the promise of providing a paradigm shift in urban mobility".

> *"Still, the critical mass for MaaS is somewhere in the future. The world has yet to see the clear evidence of benefits, better services and higher market share for customers, transport operators, regulators and MaaS providers."*
> *(Chris Lane, Head of smart travel, Transport for West Midlands)*

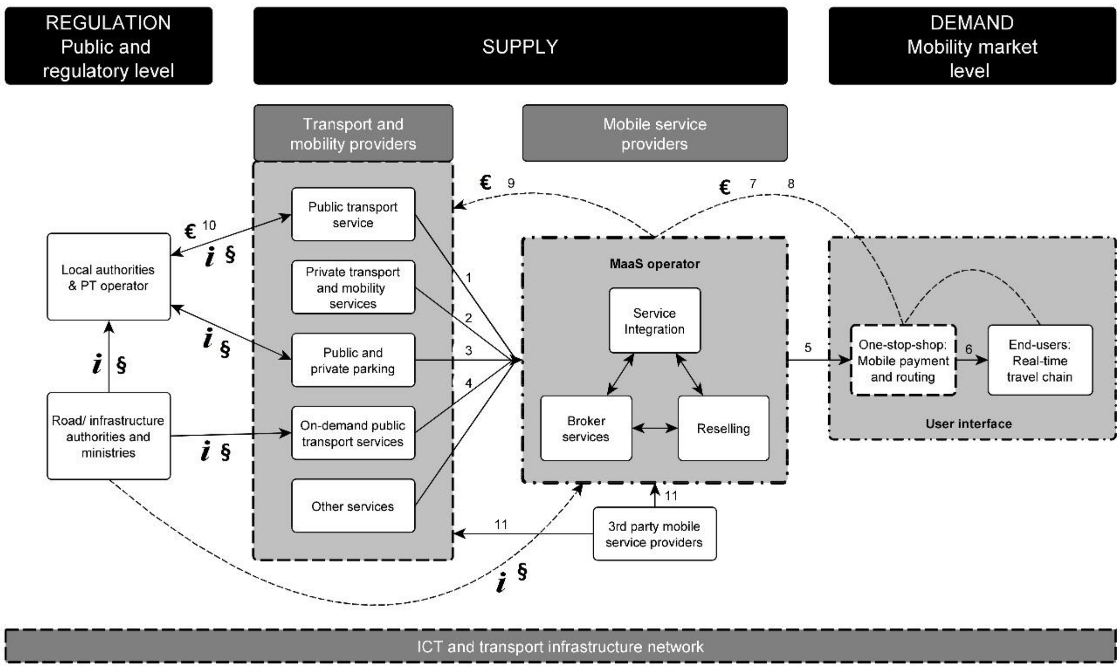
2.3.1 Ecosystem

Throughout many publications MaaS is often referred to as an "ecosystem" that considers the whole mobility sector as a cooperative, interconnected network (Catapult, 2017, Matyas, & Kamargianni, 2017 and Aapaoja, et al., 2017). A thorough understanding of the interlinkages is crucial to achieve a well-functioning MaaS ecosystem that has the potential "to boost the economic competitiveness of a city, to everyone's benefit" (Goodall, et al., 2017). The purpose is to make smarter and more efficient use of infrastructure and services instead of continuously increasing capacities (Aapaoja, et al., 2017). Same as for the definition of Mobility-as-a-Service there are a variety of conceptual frameworks for a MaaS ecosystem. Matyas and Kamargianni (2017) regard the current frameworks as exploratory and likely to be adjusted as the concept becomes more sophisticated. Nonetheless, they consider them as an important tool to scale down the complexity of this newly emerging phenomenon. For the research objectives of this study they are highly relevant as well, since the ecosystem perspective is facilitating the identification of essential factors that must be considered for a sustainable MaaS vision. Most ecosystem approaches have in common, that they include rather similar key elements, such as the transport infrastructure, mobility services, modes, and transport information, ticketing and payment services (Catapult, 2017, Matyas, & Kamargianni, 2017, Aapaoja et al. 2017). However, the denomination as well as the categorisation of elements and actors does slightly vary among the different frameworks.

In the following, the MaaS ecosystem proposed by Aapaoja et al. (2017) is being regarded more in detail since it is directly related to the research design of this study (see chapter 2.4). The framework consists of the ICT and transport infrastructure that serves as principal connector between four interacting ecosystem elements (see figure 7). These are:

(1) Public and regulatory level (Regulation)
(2) Transport and mobility providers (Supply)
(3) Mobile service providers (Supply)
(4) Mobility market level (Demand)

The regulatory level, is connected to both supply dimensions through regulative and information linkages. The second pillar includes all public and private transport as well as mobility services available at one place. Each service disposes of different information, e.g. about timetables, fares, real-time locations, availability of parking, etc. In a functioning MaaS ecosystem all this data is openly accessible. This permits the new player, the MaaS operator (third pillar), to aggregate all information from transport and mobility providers. Beside the service integration, the MaaS operator's key responsibilities are broker services and reselling while complying with the regulations that have been established by the legal authorities. This represents a crucial and exceptionally powerful role in the MaaS ecosystem, since the integrator is managing all money and information flows from and to the demand side (fourth pillar). Therefore, the MaaS operator provides a one-stop-shop (mobile app) that permits customers to access the diverse supplier's offerings. In addition, the integrated app facilitates multimodal mobility and enables real time trip planning, mobile payment, ticketing, and further traveller information. Since it is still unclear to what degree the stakeholder roles may or may not change with the emergence of MaaS, a high level of transparency, clear regulations and trust building are needed (Aapaoja, et al., 2017).



Offerings…

1. Routes, fares, timetables, real-time location
2. E.g. availability of shared cars and bicycles
3. Availability of parking
4. Location, availability and fares
5. Calculated individual (real-time) routes
6. Ticketing and routing
7. Request for information etc. (before booking and payment)
8. Booking and payment to MaaS operator
9. Booking and payment for transport (minus eventual MaaS operator commission)
10. Payment to local public transport operator
11. Key enabling hardware and software: mobile payment, routing, ticketing, etc.

Figure 7. MaaS ecosystem framework (modified from Aapaoja, et al., 2017).

2.3.2 Maturity

MaaS maturity describes to what extent an actor or a place is prepared for Mobility-as-a-Service (Goulding, & Kamargianni, 2017, TravelSpirit Foundation, 2017). Other authors refer to this phenomenon as MaaS Readiness, such as Somers and Eldaly (2016) or Aaltonen (September/2017). In order to determine the level of maturity various characteristics which are likely to have an impact on the overall MaaS ecosystem need to be assessed. A MaaS readiness evaluation can also be used to draw comparisons or to demonstrate what improvements are needed (Goulding, & Kamargianni, 2017). Generally, a distinction is made between two types of preparedness. The MaaS preparedness of individual stakeholders (potential users, transport operators, mobility providers, etc.) and of areas (city, region, country).

The stakeholder maturity considers internal aspects of different actors that are limited to their own scope and which they can influence directly (Aaltonen, 2017). This could be for instance the local transport operator's openness towards data sharing or whether a regular bus trip can be paid via mobile application (TravelSpirit Foundation, 2017). The MaaS maturity of an area has a broader range since it includes the readiness of all stakeholders in situ, as well as of the physical environment (Somers, & Eldaly, 2016). It is firmly grounded on the MaaS ecosystem concept

(Aapaoja, et al., 2017) as it takes into consideration supply, demand and regulation aspects in order to evaluate a places' readiness for Mobility-as-a-Service. These could be for example, an urban design, the current modal split or a high smartphone availability that favour an introduction of MaaS.

2.3.3 Maturity evaluation methods

In order to familiarise with MaaS maturity evaluation and to identify an adequate approach for this investigation, a methodologic review has been conducted. In total, six different indexes or set of indicators have been analysed. They are sorted after their release date in the below section:

(1) MaaS Readiness Index, MRI (Somers, & Eldaly, November/2016)
(2) Index of Openness for MaaS, IOM (Lane, & Gleave, June/2017)
(3) MaaS Maturity Index, MMI (Goulding, 2017, Goulding, & Kamargianni, 2017)
(4) MaaS Readiness Level Indicators for local authorities, MRLI (Aaltonen, September/2017)
(5) Urban Mobility Innovation Index, UMII (Taborda, Yiangou, & Georgouli, 2017)
(6) Deloitte City Mobility Index, DCMI (Dixon, et al., January/2018)

All methods have two characteristics in common. Firstly, they are all based on scoring systems and secondly, none is older than two years. The latter characteristic is not surprising, considering the fact that the MaaS concept emerged only recently and has spread since in a very rapid manner. Major differences are that some indexes focus on the evaluation of an areas' MaaS preparedness (e.g. MMI or MRI), while others concentrate principally on the stakeholder readiness (e.g. MRLI or IOM). The UMII as well as the DCMI on the other hand do not directly evaluate the MaaS maturity but rather the potential for general mobility innovations. Thus, this includes also the idea of Mobility-as-a-Service. Further differences have been observed in the type of indicators and in the applied acquisition and analysis methods.

Despite of the numerous approaches, the available information on MaaS readiness assessments remains very limited, since most of the indexes are still in development and appear to be rather unformed. This becomes especially evident when reviewing the methodologies, which in many cases are not or only insufficiently described. Due to that reason an in depth contrasting of the index designs was not feasible. Instead, the review has been resumed into a comparative chart (see table 4).

Table 4. Comparison chart of different MaaS indexes.

Index	Existing publications	Acquisition and analysis methods	Type of indicator categories	Focus of index on...	Source, *Organisation*
MaaS Readiness Index (MRI)	One conference article introducing the MRI with a comparative analysis between four cities.	*Acquisition:* Interviews, literature & database reviews, questionnaires *Analysis:* Qualitative assessment of indicator categories from 0 (=least ready for MaaS) to 3 (most ready for MaaS)	1. Availability of transport services 2. Customer demand 3. Government support and regulatory environment	the preparedness of an area, city or country towards MaaS.	Somers and Eldaly (November/2016) *MaaS Australia, MaaS Global*
Index of Openness for MaaS (IOM)	One whitepaper introducing the IOM and one case study where the index is applied on the West Midlands, UK.	*Acquisition:* Not mentioned *Analysis:* Qualitative assessment of indicator categories according to maturity levels/ steps towards openness (1=legacy closed systems to 5=advocate for open source & APIs)	1.Transport operators 2.Data providers 3.MaaS providers 4.MaaS costumers	the critical role of "openness" in the development of sustainable new mobility services. Focuses in first line on the MaaS-openness of the different stakeholders.	Lane, Gleave (June/ 2017), TravelSpirit Foundation (June/2017) *TravelSpirit Foundation and 'MaaS Lab' of UCL*
MaaS Maturity Index (MMI)	One internet document with results of a comparison between London and the West Midlands but without any background on the research design. Moreover, the thesis from index developer Goulding exists, but the document is not being shared.	*Acquisition:* Questionnaires with transport operators and authorities; literature & database reviews *Analysis:* MaaS maturity is evaluated between 0 and 1 (=most mature for MaaS). MMI includes weighting of indicators. Exact analysis steps are not described.	1. Transport operators' openness and data sharing 2. Policy, regulation and legislation 3. Citizen familiarity and willingness 4. ICT infrastructure 5. Transport services and infrastructure	the preparedness of an area, city or country towards MaaS.	Goulding (2017), Goulding and Kamargianni (September/2017) *MaaS Lab' of University College London*
MaaS Readiness Level Indic. for local authorities (MRLI)	One report where MaaS readiness of local transport authorities in five European cities is compared.	*Acquisition:* Interviews, financial statistics, etc. (no more information available) *Analysis:* Scoring of indicator categories from 0 to 5 (=most ready for MaaS). No further information on analysis methods.	1. Strategic readiness 2. Internal use 3. Shared use 4. Shared understanding	readiness of local authorities for MaaS.	Aaltonen (September/2017) *CIVITAS Eccentric*
Urban Mobility Innovation Index (UMII)	One extensive report introducing the UMII. In addition, the index assessment results for 30 different cities are portrayed.	*Acquisition:* Interviews, literature & database reviews, online survey and use of positive incentives to encourage city authorities to collaborate with data and knowledge. *Analysis:* Not explicitly described mixed-methods approach to score from 0 to 10 (=most mature for mobility innovations).	1.Readiness (Strategy; Capability; Soundness) 2.Deployment (Regulation; Investment; Engagement) 3.Liveability (Connectivity; Well-being; Environment)	assessing the maturity of a city's innovation ecosystem in urban mobility. Besides, it seeks to provide insights, deliver a guide and create a knowledge sharing platform for mobility innovation. MaaS is indirectly included.	Taborda, Yiangou and Georgouli (November/2017) *Future Cities Catapult, UITP*
Deloitte City Mobility Index	One whitepaper introducing the DCMI. In addition, more than 40 cities have been examined with the index. The respective results are outlined on separate fact sheets.	*Acquisition:* Literature review; data from government statistical databases, third party reports, private vendors and non-governmental organisations *Analysis:* Qualitative assessment of indicator categories from 1 to 5 (=closest to full future of mobility readiness)	1.Performance and resilience 2.Vision and leadership 3.Service and inclusion	assessing a city's readiness for the future of mobility. The DCMI looks at integrated and shared mobility, vision and strategy, innovation, regulation and ease of use. MaaS is indirectly included.	Dixon et al. (January/2018) *Deloitte*

Based on the review of MaaS preparedness indexes the most suitable approach for this investigation could easily be identified. The first selection criterion aimed on indexes that evaluated the MaaS maturity of an area or place. This was due to the fact that the research questions were directed on the assessment of a city's potential rather than on individual stakeholder performances. Thus, the actor-focussed IOM as well as the MRLI could be excluded. The UMII and the DCMI were never subject to selection as they were released after having established the research methodology. The second criterion was that the Index should be appropriate for the creation of a subsequent MaaS roadmap. Therefore, the tool had to consist of multi-dimensional scoring categories that permitted a deconstruction of the assessment result. This sought to facilitate the identification of MaaS-relevant weak spots which could thus be targeted in the roadmap. Both remaining indexes, the MMI as well as the MRI included this characteristic. The MaaS Maturity Index appeared to have the more sophisticated thematic coverage but there was no formal publication with detailed information about the exact methodology. Even after personally contacting the index creator Richard Goulding he was not permitted to share his methodology, as the index is currently being further adapted in cooperation with the 'MaaSLab' of the University College London (Personal communication: Goulding, 2017, November 30).

Since it was not possible to obtain more information about the MMI[1], the strongly resembling MaaS Readiness Index was selected as baseline method for this study. Just like the MaaS Maturity Index, the available information about the MRI is very rare. However, there is one conference article which introduces and shortly depicts the MaaS Readiness Index (Somers & Eldaly, 2016). Despite a general outlining of methods and steps, more specific descriptions on the thematic division, data aggregation and final result formulation are missing. In order to acquire more information regarding these gaps, the authors were personally contacted.

> *"Although we have done some further work since that 2016 publication, it has been on an in-confidence basis with some interested parties and not something that we are able to publish. We had anticipated that putting something out there would at least create a little momentum and allow others to make contributions. This seems to have been the case, at least in part, as a search for MaaS Readiness Index might also now turn up a couple of other efforts in the space."* (A. Somers, personal communication, September 12, 2017)

[1] In the meantime, the MaaSLab is actively searching for scholars that want to apply the MaaS Maturity Index (MaaSLab Website, 2018). However, no new request has been made since the research methodology had been already established at that time.

Although no further information about the MRI could be obtained, the author's answer confirmed that the index was still in development. This was already assumed since the incomplete methodological description and the comparison with other indexes had indicated some essential shortcomings of the MRI. Given these circumstances, an identical index application as in the publication from Somers and Eldaly (2016) was not possible nor recommended. Thus, in order to fill the identified gaps and to make the index suitable for this investigation the modified MaaS Readiness Index was designed. Chapter 2.4 outlines how the modified MRI was applied to this study. A detailed description about which adjustments were performed and why they were necessary is being discussed in chapter 5.1.1.

2.4 Application of modified MaaS Readiness Index

The modified MaaS Readiness Index is a tool to better answer the second research question of whether a city, area or country is prepared for Mobility-as-a-Service (Somers, & Eldaly, 2016). Together with the MaaS ecosystem understanding they represent complementary elements that serve as guidelines for a maturity analysis and for the creation of a Sustainable MaaS Roadmap.

The modified MRI represents a normatively weighted, interval-scaled index. It evaluates a set of indicators or scoring factors through a specific scoring process that "draws heavily upon the strengths of tried and tested methods for qualitative assessments […] to allow for evaluation that is repeatable and transparent" (Somers, & Eldaly, 2016). The score assignment involves converting each assessed and outlined indicator into a number from 1 to 4 which displays how favourable a factor is for the overall MaaS readiness of a site (see below). This approach helps to evaluate whether the preconditions for MaaS to function are already in place. This could be a for example, an urban design or the current modal split of a city that favours an introduction of MaaS or the availability of smartphones and mobile internet in the population.

Scoring scale

1 = no service or there is a critical barrier to be useful for MaaS

2 = some usefulness for MaaS, but below what would be desirable

3 = supportive of MaaS, but there are some gaps

4 = totally supportive of MaaS

The scoring process can be resumed in three steps:

Step 1: Condensation of acquired and analysed data into well-grounded scoring factors résumés that represent the current situation in the case site

Step 2: Verification of data accuracy of factor résumé contents through an independent auditor

Step 3: Scoring workshop with mobility experts to jointly evaluate the MRI

- At least two specialists (for this study five specialists were consulted) score each factor separately, according to their own expert criterion and to the provisioned information in the factor résumés
- The scorers reconcile individual scores to determine an agreed score for each factor

Figure 8 illustrates the thematic categorisation and the respective indicator weightings of the modified MaaS Readiness Index as it was applied in the present investigation. Furthermore, it highlights which factors are considered to be system relevant for a further MaaS development (factors > 6% weight, see chapter 5.1.1). The graphic consists of a core which is surrounded by four concentric circles. The nucleus symbolises the assessment of the modified MRI, while the surrounding rings represent the subdivided evaluation topics. The level of detail is continuously increasing from the inner to the outer ring. All factors that are included in the exterior circle are subject to be graded in the scoring workshop. In the following, the different dimensions as well as highly weighted factors are shortly being depicted:

First level dimensions (inner circle)

(1) SUPPLY → Availability of transport, mobility and communication services and infrastructure (33.33% weight)

Currently available transport, mobility and communication services and infrastructure in situ. The considerations include the coverage and usage of those options, whether there are open API's[2] or any sort of commercial agreement that allows the MaaS provider to purchase and resell mobility services.

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[2] ***What is an API (Application Programming Interface)?***
The functions of API's as well as the relevance for MaaS can easily be explained with a price comparison portal. If the website of one specific airline is used to find a flight, the indicated travel options will usually only include the flights of this supplier. On the contrary, if a flight price comparison portal is used it will show more travel options, since it aggregates information from many different airlines. This means that the comparison portal interacts with the airlines' API's. The API is the interface between the comparison portal and the multiple airline systems. It transfers the user consultation from the comparison portal over the internet to the respective airlines. It also then takes the airlines response to this request and delivers it back to the comparison portal to display it to the user who can thus book seats, choose meal preferences or baggage options. The same principle applies for all interactions between applications, data and devices. API's that allow computers to interact is what ultimately creates connectivity and makes it hence crucial for the functionality of MaaS. (whole paragraph: MuleSoft, 2015)

(2) DEMAND → Customer demand (33.33%)

Current customer demand in situ. The considerations taken into account are demographics and attitudinal factors.

(3) REGULATION → Government support and regulatory environment (33.33%)

Current level of "MaaS-friendly" policies and regulations which might foster or obstruct the introduction of MaaS.

The classification of the index into three pillars that represent supply, demand and regulation aspects has already been observed in the MaaS ecosystem concept from Aapaoja et al. (2017) or Kamargianni and Matyas (2017). In view of the complementarity of the index and the ecosystem approach, this guarantees optimal interoperability for a further construction of a Sustainable MaaS Roadmap.

The three thematic areas are further partitioned into subtopics. The supply side pillar considers by far the widest range of subjects. Thus, it requires a subdivision in second (7 factors) and third (22) level dimensions as well as in scoring factors (61) (see figure 8). With each further compartmentalisation the specificity of the factors increases while their relative weight decreases. The scoring pattern is largely similar for each supply side topic. In total, there are six different types of grading considerations that recur for the majority of overarching third level dimensions and consist of individual characteristics. They are being outlined below with an additional representative example in brackets:

(1) Coverage and service density (e.g. conventional taxi service covering the whole area of a city with a large density of x taxis per x inhabitants)
(2) Coverage and service density of mobile app service (e.g. app for conventional taxis covering as well the whole area of a city but with a much lower density since most taxi drivers do not use the app service)
(3) Service functions (assessment whether a mobility service or transport mode includes MaaS-relevant service functions, such as real-time locations, availability, price, required travel time, reservation, payment, etc.)
(4) API's (assessment whether a car sharing service, or other mobility services offer open API's, e.g. for car availability and location as well as price information, etc., that can be used by a MaaS operator in an integrated MaaS app)
(5) Modal split (e.g. of walking, cycling, public transport, etc. to evaluate service provision and usage)
(6) Infrastructure (e.g. evaluation of current conditions of transport, mobility and communication infrastructure)

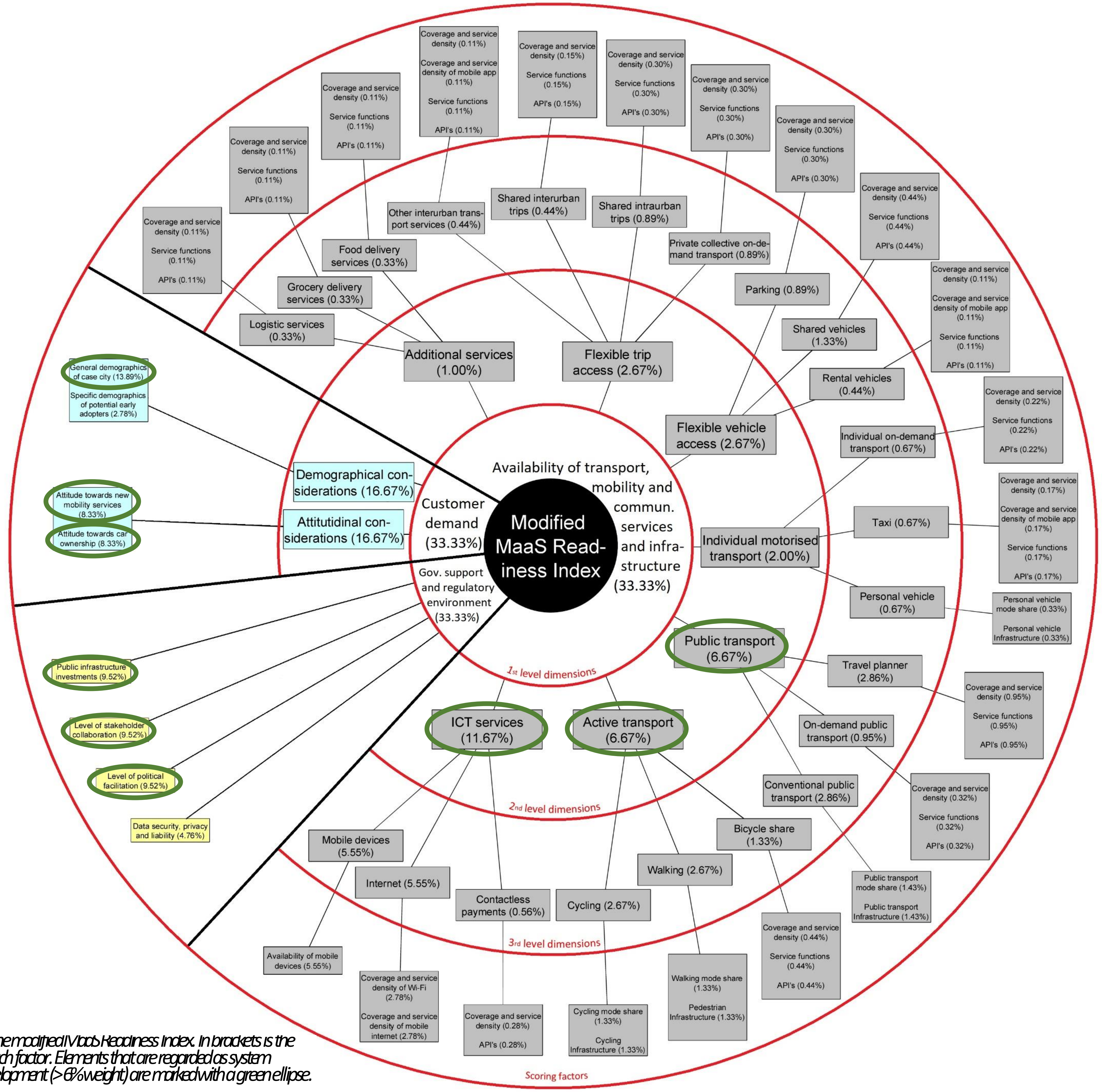

Figure 8. Overview of the modified MaaS Readiness Index. In brackets is the respective weight of each factor. Elements that are regarded as system relevant for MaaS development (>6% weight) are marked with a green ellipse.

System relevant factors for MaaS readiness were considered to be:

- ICT services (11.67%)
  - Includes: Availability and usage of mobile devices; coverage and service density of Wi-Fi and mobile internet; Contactless payment options; API's; etc.
- Public transport (6.67%)
  - Includes: Public transport mode share; Public transport infrastructure; On-demand public transport and integrated travel planner; Coverage and service density; Service functions; API's; etc.
- Active transport (6.67%)
  - Includes: Cycling / walking mode share; Cycling / walking infrastructure; Coverage and service density of bicycle share; Service functions of bicycle share; API's

Since those three topics represent second level dimensions it has to be mentioned that the according underlying aspects (third level dimensions and scoring factors) are as well regarded relatively more important than other elements in this pillar.

The demand pillar consists of two second level dimensions, the demographical and attitudinal considerations. System relevant scoring factors are:

- General demographics of case area (13.89%)
  - Includes: Population number; Population density; Urban sprawl; Urbanisation rate; etc.
- Attitude towards new mobility services (8.33%)
  - Includes: Level of openness towards sharing resources based on technology; Potential for changes in travel behaviour; etc.
- Attitude towards car ownership (8.33%)
  - Includes: Registered vehicles per population; Level of importance of car ownership; etc.

The government support and regulatory environment does not possess any second or third level dimensions since there are only four topics that did not require further grouping. Three scoring factors were regarded as system relevant for MaaS:

- Level of political facilitation (9.52%)
  - Includes: Level of current policies and regulations that favour the introduction of MaaS; Availability of open data mindsets; Plans to foster digitisation; etc.
- Public infrastructure investments (9.52%)

    - Includes: Relation of investments in car-centred infrastructure and other infrastructure types, e.g. cycling, walking, public transport; Level of availability of public funds for sustainable mobility projects or digitisation; etc.
- Level of stakeholder collaboration (9.52%)
    - Includes: Existence of Public-Private-Partnerships; Level of data sharing between stakeholders; etc.

In total, 69 scoring factors (outer circle, see figure 8) were taken into account for the assessment of the modified MaaS Readiness Index. They can provide a single weighted summary score for a study site which indicates the readiness for MaaS. In addition, the index can be used for inter-city comparisons and to demonstrate what and where improvements are required.

2.5 Research design

This investigation uses a mixed-methods (MM) approach, because of its broad research questions that address qualitative as well as quantitative components. According to Tashakkori and Creswell (2008, p. 4), mixed methods studies describe a ''research in which the investigator collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or program of inquiry''. A core assumption of mixed methods research is that it combines the strengths of both, qualitative as well as quantitative elements to help understand the research problems (Döring, & Bortz, 2016, p.17). Since the objectives of the present investigation require directly related qualitative and quantitative elements during all study phases, a fully mixed methods design was created (Leech & Onwuegbuzie, 2009). The methodological flowchart (see table 5) indicates that this study consists of three stages which are oriented on the research questions of this investigation, as stated below:

(1) What is the current situation of urban mobility in [city]?

(2) In how far is [city] prepared for Mobility-as-a-Service?

(3) What elements are to be included in a roadmap towards sustainable MaaS for [city]?

Each stage is further subdivided into four sequential categories: (a) The data needs; (b) the data acquisition methods; (c) the data analysis methods; and (d) the outcomes. The collecting of material happened thereby rather concurrently (see chapter 3.3), while the data analyses followed a separate and sequential scheme for every respective stage (see chapter 3.4). The flowchart further illustrates that the research design builds up gradually throughout the study. That is recognisable as the outcome from stage one, a descriptive analysis of the current mobility situation (see chapter 3.4.1), serves as the major data input for stage 2. Likewise, the data needs of stage 3 are fed by the index-based analysis of MaaS readiness which is the result of the previous stage (see chapter 3.4.2). With this additional data input the final purpose of this study can be achieved, the synthesis to a sustainable MaaS Roadmap (see chapter 3.4.3).

Table 5. Research design of present investigation.

	Stage one	Stage two	Stage three
Research questions	**What is the current situation of urban mobility in [city]?**	**In how far is [city] prepared for Mobility-as-a-Service?**	**What elements are to be included in a roadmap towards sustainable MaaS for [city]?**
Data needs		Descriptive analysis of current mobility situation in [city]	Assessed MaaS Readiness Index of [city]
	• Study site specific data related to mobility, transportation and urban development • Mainly quant. data, but also qual. • Optional: Origin-destination matrix	• Data about availability of transport, mobility and communication services and infrastructure • Data about customer demand • Data about regulatory environment • Quant. and qual. data needs	• Data and expert opinions related to actions, transitions, barriers, enablers, drivers, markets and services and time horizon • Best practice examples for MaaS roadmap creation • Mainly qual. data needs, but also qual. • Optional: Travel demand forecast
Data acquisition	Literature and data bank research	Literature and data bank research	Literature and data bank research
	Expert interviews	Expert interviews	Expert interviews
		Expert survey	Expert survey
	Individual questionnaire	Individual questionnaire	
Data analysis	**Descriptive analysis process** (1) Compilation and organisation of data (2) Descriptive statistics (3) Creation of chapter that describes the current mobility situation	**Index-based analysis process** (1) Analysis of data a. Descriptive statistics b. Qualitative Content Analysis (2) Allocation of compiled and analysed data to one or more MRI scoring factors (3) Condensation of data into well-grounded factor résumés (4) Verification of data accuracy through an independent auditor (5) Scoring workshop with mobility experts to jointly evaluate the MRI and subsequent graphical presentation of result	**Roadmap synthesis process** (1) Preliminary theoretical considerations about roadmap construction (2) Screening of MRI assessment results → System-deficit analysis (3) Analysis of data a. Descriptive statistics b. Qualitative Content Analysis (4) Synthetisation into roadmap and graphical presentation of result
Outcomes	Description of current mobility situation in [city]	Assessed MaaS Readiness Index of [city]	MaaS Roadmap for [city]

In order to comprehensively outline each category for all research phases, four essential questions have to be asked:

- *What data is needed?*
- *How to acquire this data?*
- *How to analyse this data?*
- *What outcome is expected?*

The **first stage** of the research design is characterised by a broad need for mainly quantitative but also qualitative data related to the study site's mobility and transportation sector. Most of the data could be obtained by an in depth literature and data bank research. Moreover, an individual questionnaire addressed to the local transport authority delivered additional quantitative data while expert statements about the study site's mobility were conceived through interviews.
Since the outcome of stage 1 is a descriptive portrayal of the status quo of urban mobility at the study site, a compilation and thematic organisation of data occurred as well as basic quantitative data analysis, such as descriptive statistics. Ultimately, this information was presented in a chapter about the current mobility situation (see chapter 4.2).

For the **second stage**, the application of the MaaS Readiness Index clearly showed the indicator-specific qualitative and quantitative data requirements. Overall, data was needed for 69 indicators which were grouped into the three pillars of the MaaS Readiness Index (see chapter 2.4). The study area's descriptive mobility analysis from the previous stage served as principal source for all three index dimensions and for the underlying indicators. Particularly, the collected quantitative data resulted thereby very useful for the first pillar of the MRI. Still missing information were acquired through a mix of different acquisition methods which include literature and data bank revision, expert interviews and an expert survey about the potential for new mobility services at the study site.
The following data analysis consisted of five principal steps. The first step was to analyse data through descriptive statistics as well as a qualitative content analysis. Then, in step number 2 the primary and secondary data were allocated to one or more scoring factors of the MRI, depending on thematic suitability. In step 3, the accumulated information for each indicator were condensed to well-grounded factor résumés that represent the status quo in the case city. In the fourth step an independent auditor needed to confirm the accuracy of the factor résumé contents. As fifth step a scoring workshop with mobility experts was held. Their task was to revise and score each factor with the provided data as well as with their own expert criterion. After having graded all factors individually a second scoring occurred. This time the specialists

needed to discuss and form consensus for each factor score which led to a final MRI grade for the study site. Consequently, the index assessment outcomes were graphically represented what permitted for further processing in stage three.

The **third stage's** principal data need was the just mentioned result from the MaaS readiness analysis. Additional data requirements were best practice examples for roadmap constructions as well as mainly qualitative data about potential drivers, obstructers, markets, services, enablers and the time horizon. Just as for the other two stages, a mixed methods strategy was used to acquire the data that the MRI assessment could not provide. The most important data acquisition tools were once again the review of literature sources and the conduction of expert interviews. The standardised expert survey about new mobility services was also considered an important tool.

In order to synthesise the data into a MaaS Roadmap four steps had to be taken. The first step included preliminary theoretical considerations on how to create a roadmap. Step two included a review of the MRI scoring results. The index served thereby as weak point identifier as it revealed system relevant indicators (high weighting) with low scores (bad performances). This methodology made evident that the roadmap's actions and transitions had to be addressed mainly to these areas. Step number three was directed to the processing and interpretation of data. This included a qualitative content analysis of the interview transcripts as well as descriptive statistics of the expert survey. This clear procedure facilitated the subsequent synthetisation into a sustainable MaaS Roadmap. At last, a graphical representation of the final roadmap had to be composed.

3 Methodology

3.1 Data quality

Mixed methods (MM) research has steadily increased in popularity in the past decades (Johnson, & Onwuegbuzie, 2004, Tashakkori, & Creswell, 2007). The benefit of this approach is that the research problem can be more fully addressed, and that the combination of different strategies and data sources can provide better assurance of results (Döring & Bortz, 2016, p. 17). Various authors describe it even as third research paradigm besides the qualitative and quantitative investigation (Greene, & Caracelli, 2003, Tashakkori, & Creswell, 2007, Gunasekare, 2015). As a consequence of this development, clear guidelines on how to conduct each step of mixed methods studies have emerged. This includes as well specific MM quality evaluation strategies. Although there is no consensus yet, a review by Heyvaert et al. (2013) has found that most authors agree that appraising qualitative and quantitative strands separately is too limited. Mixed methods research "is more than simply the sum of its […] elements" (Heyvaert, et al., 2013). Nonetheless, the common qualitative (credibility, dependability, transferability, confirmability) and quantitative (internal validity, reliability, external validity, objectivity) quality criteria still have to be met in MM studies (Döring, & Bortz, 2016, p. 114). In the following an exemplary overview describes which strategies were used to ensure rigour/ robustness for the present research.

The techniques for qualitative elements include the capturing of multiple subjective viewpoints (expert interviews) to gain a great range of perspectives. Furthermore, interview findings were taken back to participants (e.g. interviewees that were as well participants in the expert workshop) to get their opinions on interpretations drawn from their interviews. This so called respondent validation seeks to ensure credibility and dependability of qualitative studies (Hadi, & José Closs, 2016). In order to obtain transferability a "rich and thick description" about all steps of research has been performed. This allows readers of this study to evaluate whether the authors conclusions are transferable to other settings, situations and populations (Morse, 2015). Other used techniques were self-reflections to reduce researcher bias, external audits (e.g. for verifying accuracy of factor résumés) or peer debriefing. Debriefing describes the process in which a researcher discusses the research methodology, data analysis and interpretations continuously with a peer (Morse, 2015). It supports ensuring credibility and trustworthiness. In case of this investigation, the peers have been the thesis supervisors and other skilled researchers.

For the quantitative elements, the author aimed on consulting data principally from reliable and objective sources, such as peer-reviewed publications and major transport related institutions that constantly update their statistics. But since this research is treating a cutting edge topic, high quality data, in particular about MaaS-specific aspects, are still rare. As a result, sometimes even non-peer reviewed literature, slightly outdated facts or data where the inter-comparability appeared suboptimal had to be taken into account in. The latter occurred for instance when different geographic delimitations were used to describe the same transport characteristic. With the purpose to transparently highlight eventual quality constraints, the respective sources were graded in reliability levels from low to high (see chapter 3.3.1 and annex 1). One example in order to further increase validity expert survey results was to apply an appropriate statistical analysis for it.

Beside ensuring rigour and robustness for qualitative and quantitative research components, it was additionally required to comply with MM quality standards (Döring, & Bortz, 2016, p. 114). Therefore, the GRAMMS framework by O'Cathain, Murphy and Nicholl (2008) was applied. GRAMMS stands for "Good Reporting of A Mixed Method Study". It is a guideline to assure the quality of MM research by properly documenting every stage of an investigation. GRAMMS consists of six steps that are mentioned below. An indication in parentheses after each framework step, shows in which chapter(s) the respective documentation can be found.

GRAMMS (O'Cathain, Murphy, & Nicholl, 2008):

(1) Describe the justification for using a mixed methods approach to the research question (see chapter 2.5)
(2) Describe the design in terms of the purpose, priority and sequence of methods (see chapter 2.5)
(3) Describe each method in terms of sampling, data collection and analysis (see chapters 3.2 - 3.4.3)
(4) Describe where integration has occurred, how it has occurred and who has participated in it (see chapter 3.2 – 3.4.3 and 5.1 – 5.2)
(5) Describe any limitation of one method associated with the presence of the other method (see chapter 6)
(6) Describe any insights gained from mixing or integrating methods (see chapter 6)

3.2 Data needs

Since this investigation is using a mixed methods approach, both quantitative as well as qualitative data were required to address the respective research questions.

The **first research question** is directed on the description of current urban mobility at the study site and required a set of transport and mobility related information ranging across all three dimensions of sustainability (social, environmental, economic, Hietanen, 2016). This includes mainly quantitative data about demography, the modal split, air pollution, public investments in infrastructure as well as qualitative data about the satisfaction with the transportation system or many others. For a more complete panorama an origin-destination matrix would have been desirable but the effort of additional data collecting was considered as too time demanding and hence neglected.

The data needs for the **second research question** were oriented towards the index-based analysis of MaaS maturity. They could be directly read from the indicator denominations of the MaaS Readiness Index and partly retrieved from the results of the previous research question. The data-intensive assessment of the MRI required a variety of quantitative and qualitative data for the three dimensions of the index. This includes data about the current smartphone coverage, number of taxis, modal split, existence of shared mobility means, etc. for the first MRI pillar. In the second pillar information about demography and attitudes were required in order to evaluate the customer demand. For the third pillar, data related to infrastructure investments, multi-stakeholder collaboration and political facilitation for new mobility services were needed.

The most crucial data need for the **third research question** was the assessed MaaS Readiness Index. Apart from the MRI analysis, principally qualitative data about drivers (social, technological, financial, ecological, political), obstructers, markets, new mobility services and enablers (funding, networks, know-how, etc.) were required. Furthermore, best practice examples served as guideline for the synthetisation of the final MaaS roadmap. An additional travel demand forecast was regarded as optional and hence not considered for the same reasons as the origin-destination matrix.

3.3 Data acquisition

This investigation is using four different methods to collect data. These are, the literature research (see chapter 3.3.1), expert interviews (see chapter 3.3.2) as well as an expert survey and an individual questionnaire (see chapter 3.3.3). In part, a supplementary scoring workshop could also be included as additional data collection tool. This is due to the fact that the focus-group similar character of the method can give new insights into the topic, although its first objective is to jointly analyse the indicators of the MaaS Readiness Index (see chapter 3.4.2). The mixed methods approach becomes visible as each research question requires a different combination of acquisition methods (see table 5 in chapter 2.5). Particularly, the literature research as well as the expert interviews can be regarded as principal data acquisition tools while the individual questionnaire is considerably less important.

Data acquisition methods for research stage 1:

Most of the required information could be obtained by an in depth literature and data bank research (e.g. statistical sources like INEGI, ITDP, etc.). Further raw-data were supposed to be acquired through an individual questionnaire addressed to the local transport authority. In practice however, only a very limited amount could be collected using this channel. To a likewise small extent, the expert interviews provided additional quantitative as well as qualitative data.

Data acquisition methods for research stage 2:

The data that were compiled for the objective of the first research stage served as major data input for the indicator set of the MaaS Readiness index. The collected data on the current mobility situation originated from different data acquisition methods and sources as described in the previous paragraph. Still missing data could be additionally acquired by a survey about the potential of new mobility services and through expert opinions retrieved through interviews.

Data acquisition methods for research stage 3:

The main data source was the output of the second research stage, the assessment result of the MaaS Readiness Index. The respectively required data acquisition tools are described in the above paragraph. Additional collection methods for the third research phase comprise literature and data bank research, expert interviews as well as the expert survey.

3.3.1 Literature research

The literature search is an essential part of every research project and can be divided into two main areas. The literature relevant to the topic and the literature on research methodology and data collection techniques (Hart, 2001). The thematic literature is used to identify knowledge gaps and key studies, to establish the theoretical framework and to raise research questions (Hart, 2001). However, the literature on methodological aspects helps to contrast different approaches and to construct the research design (Hart, 2001). In this investigation the literature and data base search represents the principal data acquisition method as they can provide data for both, thematic and methodologic research stages. In order to effectively search and organise relevant material, the following six-step-strategy has been developed:

(1) Defining a clearly delimited topic

The delimitation of the topic is oriented on the research questions, i.e.:

- Analysis of current mobility situation,
- evaluation of MaaS maturity and
- construction of a MaaS roadmap
  for a selected study site

(2) Identifying specific search terms

Listed below are the most relevant search terms which were used in multiple different wordings and combinations:

- Mobility-as-a-Service; MaaS; Roadmap; Readiness; Maturity; Index; Ecosystem; Integrated mobility; Mulitmodal; Intermodal; Smart mobility; Smart city; Sharing economy; Shared mobility; Disruptive technology; Digitisation; Urbanisation; Mobility transformation; Carsharing; Bikesharing; Public Transport; Modal split, etc.
- Other study-area-specific search terms

(3) Searching for literature

Using online sources:

- Scopus; Web of Science; ScienceDirect; BIG (Búsqueda de Información Global); Springer Link; Wiley Online Library; Google Scholar; Google; Online libraries of TH Köln and UASLP; Specific databases relevant for study area (INEGI, ITDP, etc.)

Other sources:

- Libraries of the TH Köln and of the UASLP; Newspapers

(4) Sampling of literature

The literature was filtered according to four selection criteria which were adapted from Hart (2001):

- *Authority:* Articles in peer-reviewed journals and materials published by reputable publishers, authors and institutions
- *Fundamentality:* Works regarded as having significantly developed the topic
- *Currency:* Generally, past 3 years for specific MaaS literature and past six years for other topics, excepting seminal works
- *Relevance:* Topic-specific; Within the parameters of the aims of the project

(5) Evaluation of literature

Since the data availability was considered principally low for MaaS-related aspects, sometimes even suboptimal material had to be taken into account. Therefore, a quick assessment of the literature based on the previously mentioned authority and currency was performed. This permitted to classify their quality from whether as low, medium or high (see annex 1).

(6) Organisation of literature

A categorised database of all relevant published material has been created on the reference management program Citavi. The categorisation was analogous to the chapter structure of the thesis. When initially entering an article to Citavi it had to be assigned to all chapters it appeared relevant for. This allocation of literature into different groups was dynamically modifiable during the investigation process. This became necessary, particularly when a more detailed look on the source revealed that it was as well suitable for another category. The clearly structured information allowed rapid access during all stages of research.

In order to review seminal literature about different MaaS indexes as well as relevant data for the assessment of the MaaS Readiness Index other organising structures had to be selected:

- *Literature about MaaS indexes (see table 4 in chapter 2.3.3)*

  A tabular structure to compare all identified approaches of measuring MaaS maturity was created. The table consists of the following elements (see table …):
  - Existing publications
  - Acquisition and analysis methods
  - Type of indicator categories
  - Index focus
  - Source, Organisation
- *Literature and statistical data table for the assessment of the MRI (see annex 1)*

  *Any k*ind of information, such as statistical data and quotes data that were directly relevant for the assessment of the MaaS Readiness Index, were integrated into a tabular database with a thematic classification oriented on the level dimensions of the MRI.
  - First level dimensions
  - Second level dimensions
  - Third level dimensions

- Scoring factors
- Source of information
- Data quality
- Gathered information

3.3.2 Expert interviews

Experts have technical, process and interpretation know-how related to a specific professional field of action (Bogner, & Menz, 2005, p. 46). Their opinions and understandings are regarded as crucial in order to address the objectives of this investigation. Thus, explorative expert interviews have been applied as they aim on the familiarisation with emerging concepts (Bogner, Littig, & Menz, 2014, p. 23). The collected qualitative data[3] was thereby particularly useful for the assessment of the MaaS Readiness Index and the subsequent creation of a MaaS Roadmap.

Before the interviews

The preparation of the interviews required a careful development of guidelines. Such guides have a dual function: They structure the subject area of the investigation and serve as orientation instrument in the interview situation (Bogner, Littig, & Menz, 2014, p. 27). Therefore, the before mentioned research design flowchart (see table 5 in chapter 2.5) and the literature and statistical data table (see annex 1) were consulted. The contrasting of both elements displayed data gaps and indicated which of these information lacks were likely to get filled through expert interviews. Based on this background, open interview questions were formulated and compiled into an interview question database which served as baseline guide (see annex 2). The questions were catalogued into topics and subtopics which aligned to the three principal research objectives. In a second categorisation each question was allocated to potential interviewees. In order to further systemise the table, the interviewees were grouped into different types of experts (public administration, academia, interest association, etc.) and a filtering function was included. This clear structuration facilitated the process of creating customised question catalogues for each expert. For instance, when applying the filters "attitude towards car ownership" AND / OR "academia" all questions related to this topic and / or expert type were displayed and could thus be used to extract questions for an individual interview guideline. Subsequently, the questions were prioritised for each guideline into principal and detailing questions. Since expert interviews are always semi-structured and reactive to the

[3] But also quantitative data, e.g. when the interviewees mentioned exact statistical numbers.

respondent, an orienting but non-binding chronological order of the questions was additionally defined (Bogner, Littig, & Menz, 2014, p. 27).

The preparatory work also included considerations about the field access like the sampling and the contacting of experts. The sampling has been performed by asking four essential questions as described below (Gorden, 1975, pp. 196-197):

(1) Who has the relevant information?
(2) Who is most likely to give accurate information on the situation?
(3) Who is most willing to give information?
(4) Who among the experts is available?

For contacting the sampled out experts two channels were used. Either they were approached personally via E-Mail, telephone or face-to-face or the contact was established directly through a recommendation from other experts. Afterwards, appointments for the interviews which were mostly made in person had to be arranged. Seldom, the interviewees asked to receive the question guide before the interview. For reasons of building trust these wishes could not be refused. Nevertheless, the default procedure was to not send the question catalogue prior to the meeting. In one case though, the respondent preferred to answer to the interview questions in written form. Accordingly, the specific guideline with open questions was sent to that person who answered it in writing.

During the interviews

For an effective data documentation all interviews were held in quiet environments and recorded with a high quality device. Each interview includes general starting and ending remarks which were spoken on the sound recording by the interviewer. That happened in the presence of the interviewee which corresponded at the same time as consent to the recording. The documented outlining information were: date, place, starting time, ending time, name of the interviewed person as well as additional persons present[4]. In order to further increase trust, the respondents were informed that the obtained knowledge would be used only for scientific purposes.

As it could be assumed that some experts would not be completely familiar with the concepts and definitions this investigation was treating a very condensed depiction of the theoretical framework was performed when it appeared necessary. Whether as oral explanation or by showing a two-minute-long explanatory video (see annex 11) which illustrated the basic concepts used in this research.

[4] In one case an interview has been made simultaneously with three experts.

During the interview situation the investigator roughly followed the seven general rules of how to conduct an interview proposed by Gläser and Laudel (2010): listening actively; asking flexibly; clarifying not-understood comments; asking for details; asking short and clear questions and avoiding to evaluate. Directly after the interviews memos with general remarks about the conversation were annotated.

3.3.3 Expert survey and individual questionnaire

For this investigation two types of questionnaires were required. One for an expert survey to evaluate the study site's potential for new mobility services (NMS) and another individual questionnaire to compile mobility related data from the local transport authority. A questionnaire preparation checklist proposed by Schneider (2013, p. 131) served as guideline. The online query platform Google Forms was selected for the questionnaire creation and dissemination, as well as for answering by the participants. In order to identify relevant questions, the same procedure as for the interviews was applied. Meaning that the contrasting of the research design flowchart (see table 5 in chapter 2.5) with the literature data table (see annex 1) permitted deducing which data gaps could be filled by each questionnaire. This facilitated a target-oriented phrasing of questions.

Technically speaking, both forms are semi-standardised as they include questions with predetermined answers as well as questions that can be responded in writing. However, regarding them more closely reveals their rather standardised characters. That becomes recognisable in the individual questionnaire that although many questions can be answered by text, they are not formulated openly. The questions consist mostly of instructions like "how much", "who" or "mention" and only seldom of "how", "why" or similar. That implies that most of the questions are finally directed towards collecting quantitative data and factual knowledge. In the case of the expert survey all questions, except of one which is openly formulated, can be answered by choosing between predetermined answers. These answer options reflect sets of hypothetical expert opinions which were deduced from literature and from the interviews. However, the respondents have the possibility to add "other" answers or comments if they do not find an adequate response option. This text is then subject to a qualitative analysis, in contrary to the rest of the survey which can be assessed quantitatively. Table 6 shows which answer types were considered most suitable for each questionnaire. Before finally launching the questionnaires, they were furthermore pre-tested as suggested by Kallus (2016, pp. 77-80). Therefore, two independent evaluators who are related to the research topic and to the study area assessed the content, the relatedness to the research objectives, the intelligibility, the question wording (logic and grammar) and the layout design.

Table 6. Description of answer types and indication in which questionnaire they were principally used. A dark grey field means that this has been the "principal answer type", light grey stands for "secondary answer type" and blank stands for "has not been used". The text in italic letters represents examples for the appropriate assignment of answer types.

Answer type	Description	Expert survey	Indiv. quest.
Short answer	• Permits only very short text answers ➔ *E.g. for numeric answers or a short mention of facts*		[dark grey]
Paragraph	• Permits slightly longer text answers ➔ *E.g. for a description*	[light grey]	[dark grey]
Drop down	• Set of predetermined options • Participant can only choose one option ➔ *E.g. for closed questions with fix answers*	[light grey]	[dark grey]
Multiple choice	• Set of predetermined options • Participant can choose only one option • May include "Other" as an option, where people can type a short answer ➔ *E.g. for closed questions with fix answers "Other"*	[dark grey]	[light grey]
Checkboxes	• Set of predetermined options • Participant can choose more than one option • May include "other" as an option, where respondent can type a short answer • May include specific rules (e.g. select max 3 options) ➔ *E.g. when the responders shall indicate in which geographic area the implementation of new mobility services would be most relevant*	[dark grey]	[light grey]
Multiple choice grid	• Grid where participant can select one answer per row or column ➔ *To evaluate various answer options on a scale; e.g. from "1" to "10" or "extreme decrease" to "extreme increase"*	[dark grey]	[dark grey]
Checkbox grid	• Grid where participant can select one or more answers per row or column ➔ *To contrast two elements; e.g. stakeholders and their roles*	[light grey]	

Expert survey about new mobility services at the study site

Maestas (2016) describes the "expert survey as particularly useful for measuring concepts that would be difficult to assess through alternative strategies". In line with this quote, the expert poll sought to evaluate the still unstudied potential for new mobility services (NMS) in the case city. This data collection method provided information for the MRI assessment as well as for the MaaS Roadmap. Especially regarding the second and third pillar of the MaaS Readiness Index. The most important data acquisitions for the roadmap were the opinions about the temporal horizon of NMS development as well as information about the different roles of stakeholders and preconditioning factors, among others. It was deliberately avoided to denominate the poll a survey about Mobility-as-a-Service, since the concept is still largely unknown, even among specialists. However, the addressed experts had a deep understanding of urban mobility in general and were familiar with the rise of new mobility services. They were practitioners in mobility and urbanism from politics, academia, private sector and civil society organisations what allowed them to give well-founded answers. Different channels were used in order to acquire a broad range of participants. The first and most important one was through personal communication and word-of-mouth recommendation, in particular through experts who were previously interviewed. Another method was applied during the “Forum of Urban Intelligence”[5] where the thesis author approached the conference attendees and invited them personally to participate in this expert poll about new mobility services. Moreover, an internet research has been performed to identify further relevant stakeholders which were notified about the survey by E-Mail or via the social media platform Facebook.

The final survey constitutes of 12 sections (see annex 5). The introduction part gives brief background information about the topic and the survey outlines. In the second section the participant is asked for general personal information that can be used for a categorisation into different profile groups. The following eight chapters represent the main content, including altogether 15 core questions which are subdivided as described below:

- Functions of NMS for the case city
- Relevance of NMS for the case city
- Suitable geographical areas for the implementation of NMS
- Potential impacts of NMS for the case city
- Stakeholder roles in the NMS implementation process for the case city
- Fundamental aspects for the implementation of NMS in the case city
- Time horizon of the implementation of NMS in the case city
- General questions about NMS for the case city

The last two sections of the survey are for feedback and to express thanks to the participant.

Individual questionnaire to compile mobility related data about the study site

This questionnaire served the purpose to deliver principally quantitative data that could not be obtained through other methods. The collected information was used for the portrayal of the current mobility situation at the study site and for the assessment of the MRI. It has been exclusively applied to the local transport authority as it was to be assumed that this institution would possess unique access to a large share of the requested data. In practice however, this acquisition method resulted rather inefficient since the transport authority provided only a very limited amount of data. The invitation to fill in the form has been made personally after an interview with the secretary of the transport authority.

The final questionnaire constitutes of eleven sections (see annex 7). The first section outlines a general introduction while the second describes two key instructions with the purpose to prevent imprecise answers. Instruction number 1 sets a clear geographical delimitation for the study area that is additionally displayed in a map. In case the data available to the institution does not correspond to the default area alternate boundaries have to be indicated. The second

[5]Foro de Inteligencia Urbana: San Luis Potosí, 05th - 08th of December 2017

instruction is to acquire the most recent data possible. If the information does not refer to the default year 2017 the responder has to state to which year, the data refers to. The following seven chapters of the form include in total 41 questions that are thematically subdivided as listed below:

- Individual motorised transport
- Public transport and taxi
- Uber (ride-hailing service)
- New mobility services based on mobile devices
- Mobile internet and public Wi-Fi
- Investments, subventions and incentives in transport and mobility
- Fuel types and emissions

In order to further increase the data quality of this inquiry, some questions include a subsection where the responder has the possibility to auto-evaluate the reliability of the given information. The last two sections of the questionnaire are for feedback and to express thanks to the participant.

3.4 Data analysis

On the contrary to the previous data acquisition methods that were performed mostly concurrently, the data processing has occurred rather sequentially. The analysis sequences were oriented on the three research stages (see table 5 in chapter 2.5) that permitted a subdivision in three respective chapters with descriptions on how the different analysis steps were performed. These are:

(1) Descriptive analysis of the current mobility situation at the study site (see chapter 3.4.1)
(2) Index-based analysis of readiness for MaaS at the study site (see chapter 3.4.2)
(3) Process of MaaS Roadmap synthesis for the study site (see chapter 3.4.3)

Each analysis stage consists of combined quantitative and qualitative data processing steps that highlight once again the mixed-methods character of the present paper. In quantitative data analysis, numeric data are statistically evaluated with respect to the objectives of an empirical study (Döring & Bortz, 2016, p. 612). Qualitative data analysis on the other hand, evaluates qualitative material with regard to an exploratory interest and is highly inductive (data-driven) (Döring, & Bortz, 2016, p. 599).

In particular, two methods shall be emphasised here. These are descriptive statistics (quantitative data analysis) as well as a qualitative content analysis (QCA) (qualitative data analysis). Since these two methods recur in every analysis stage and in order to avoid repetitions, they are being outlined in this chapter while the subchapters 3.4.1 - 3.4.3 focus primarily on the description of the respective analysis steps and on their combination of methods.

Descriptive statistics were used to outline basic features of the collected and generated data. This method cannot be used to make any statements on a population that goes beyond the researched samples (Atteslander, 2010, p. 304). Nonetheless, it can provide simple summaries and graphic analysis for relevant data and processes (Döring & Bortz, 2016, p. 612). Whether the usage of tables, pie charts, histograms or other representations is most appropriate, depends on the scale of measurement of the underlying data (Döring, & Bortz, 2016, p. 612).
Analysed quantitative material that originated from literature, statistical databases, or very marginally, from the individual questionnaire, were principally utilised for two purposes. For the description of the mobility situation in the case city and for the first pillar of the MRI, that regards the availability of transport, mobility and ICT services. The survey findings on the other hand were required for pillar two (customer demand) and three (regulative environment) of the index-based assessment as well as for the roadmap.

The **qualitative content analysis** aims to create a systematic and intersubjectively verifiable analysis that, despite the need for interpretation, meets scientific requirements (Döring & Bortz, 2016, p. 541). It is based on a principally inductive coding process of text segments with the purpose to retrieve and structure manifest and latent contents (Döring, & Bortz, 2016, pp. 540-544, Mayring, 2016, pp. 114-121). In order to conduct a QCA, the interview recordings were completely transcribed avoiding any sort of smoothing the wordings (see annex 3). The subsequent analysis oriented on the model for inductive creation of categories, proposed by Mayring (2016, p. 116, see figure 9). It has been carried out with the qualitative data analysis software Atlas.ti:
In the first step, preliminary considerations were required to guide the determination of categories and

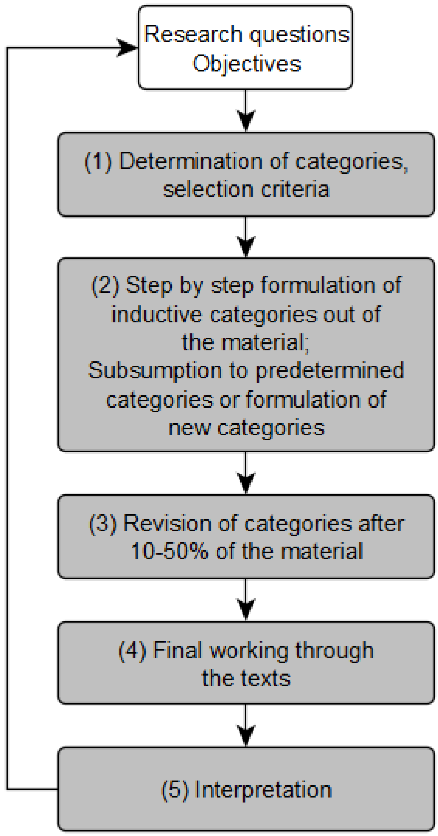

Figure 9. Model of inductive category formation (Mayring, 2016, p. 116).

selection criteria that needed to be directly linked to the research questions. This represents a deductive element in an otherwise mainly inductive process. In this investigation, the highly ramified MRI as well as theoretical considerations about the roadmap allowed to deduce a variety of categories. Subsequently, the material had to be reviewed line-by-line while formulating inductive categories from relevant text passages (step two). Depending on their thematic suitability the inducted categories could be subsumptioned to other categories or used as new categories. After having reviewed 10-50% of the material the category catalogue was checked (step three), which included actions, such as merging potentially ambiguous categories or identifying most relevant aspects. In step four, the remaining material was analysed and coded with the updated category catalogue. Thereafter, the data was interpreted with specific regard to the research questions (step five). The aim was to identify interconnections of the categories that supported the assessment of the MaaS Readiness Index as well as the roadmap synthesis.

3.4.1 Descriptive analysis process

Since the objective of the first research question aimed on a simple description of the current mobility situation instead of a profound interpretation, the analysis needs were rather low. Basically, they focused on descriptive statistics of the collected data as well as on a structured compiling and contrasting of mobility related information. A favourable fact was that many data were already pre-processed when retrieving them, particularly those from reliable statistical sources (e.g. INEGI, ITDP) which reduced the overall need for analyses. The descriptive statistics analysis targeted the appraisal of mobility related characteristics like the current modal split, motorisation rate and transport fatalities per year, among many others. Qualitative analysis methods were not directly applied for this investigation phase. However, the QCA that was performed in the framework of the index-based analysis and the roadmap synthesis provided some generic conclusions about the case city's mobility situation as well. It could be argued that this outcome represents rather a by-product of the QCA which goes beyond the objective of the first research question. Nonetheless, it could not just be disregarded and was thus included in chapter 4.2, which describes the status quo of urban mobility in the case city. This situation highlights that a clear separation of instruments is neither always possible nor intended in mixed-methods approaches. The compiled and descriptively analysed data were later converged into the chapter about the current mobility situation at the study site that addresses the purpose of the first research question (see chapter 4.2).

3.4.2 Index-based analysis process

The second research stage was directed towards an index-based analysis to assess the current MaaS readiness of the case city. The centrepiece of this analysis was a MRI scoring workshop with local mobility experts in order to jointly evaluate the preparedness of the case city for Mobility-as-a-Service. However, before being able to assess the case city's maturity level for MaaS one preliminary condition needed to be met, the modification of the MaaS Readiness Index. Since the original MRI proposed by Somers and Eldaly (2016) presented certain shortcomings and lacked of a complete description, it was not possible nor recommended to apply the index identically to this research (see chapter 2.3.3). Hence, the index has been remodelled including a redefinition, reorganisation, and weighting of scoring factors. Moreover, system relevant factors were determined.

Since the adjustment of the MRI required discussing the reasons for the performed changes it is not included in the present chapter, but outlined more in detail in chapter 5.1.1. Excluding the preliminary consideration about the modification of the index, the actual MRI has been analysed in five steps:

(1) Analysis of data
    - Descriptive statistics
    - Qualitative content analysis
(2) Allocation of compiled and analysed data to one or more scoring factors of the MRI
(3) Condensation of data into well-grounded scoring factor résumés that represent the current situation in the case site
(4) Verification of data accuracy of scoring factor résumés through an independent auditor
(5) Scoring workshop with mobility experts to jointly evaluate the MRI
    - At least two specialists (five specialists were consulted for this study) score each factor separately, according to their own expert criterion and to the provisioned information in the factor résumés
    - The scorers reconcile individual scores to determine an agreed score for each factor
    - Graphical presentation of result

In **step one**, data that was still untreated had to be prepared and analysed in order to serve as accurate baseline information of the scoring factor résumés (see step three). Since a large amount of the required data originated from the results of the descriptive analysis in the first stage, they were already processed. Thus, additional analysis needed to be focussed basically on two types. This included descriptive statistics for the expert survey as well as a qualitative content analysis for the interviews (see chapter 3.4).

The **second step** has an extensive temporality as it runs rather parallel from the general acquisition of data, to the descriptive mobility analysis, until the finalisation of the above mentioned step one. This process describes that directly upon data acquisition (or analysis if necessary), the material is allocated to one or more topics of the MaaS Readiness Index. For instance, when a relevant information like the modal split has been identified it was immediately attributed to the respective scoring factors “mode share walking/ cycling/ public transport/ private motorised transport”. In total, there were 69 scoring factors that constituted of their respective pool of data.

In **step three** all available data for each of the scoring factors had to be to condensed to well-grounded status quo factor résumés. They served as baseline decision support for the subsequent scoring workshop. This methodological step follows the MRI approach from Somers and Eldaly (2016). The reason for the condensation of information was that the amount of data which could have potentially been used to evaluate each area was too extensive. Otherwise the revision by the independent auditor (step four) or the joint assessment in the workshop (step five) would have simply taken too much time what might not have been appealing to potential participants. In order to further lower the barriers of expert collaboration, all factor résumés were outlined with their respective condensed contents in form of a slide show.

Step four of the index-based analysis consisted of a verification of the résumé’s data accuracy, which was also proposed by Somers and Eldaly (2016). The auditor needed to be an expert in smart mobility as well as familiar with the study site. With the purpose to find an adequate validator the four-question sampling strategy from Gorden (1975, pp. 196-197) was used. This strategy was already applied in chapter 3.3.2. Following the identification of a suitable candidate the scoring factor summaries were shared with him/ her and subjected to a thorough examination. In order to properly document the methodology an additional written form was prepared where the auditor described his/ her expert background and confirmed the accuracy of the indicator résumés (see annex 9).

Step five – Expert workshop for scoring of Maas Readiness Index

After having concluded all the previous steps, the expert workshop has been performed. This workshop served the purpose to score all indicators of the MaaS Readiness Index through the mutual consultation of a group of mobility-related experts from politics, private sector and academia. The scoring process “draws heavily upon the strengths of tried and tested methods for qualitative assessments […] to allow for evaluation that is repeatable and transparent”

(Somers, & Eldaly, 2016). In order to depict all phases of the workshop, they were structured into a chronological checklist as stated below:

Direct preparations for the workshop

- ✓ Create a slide show
  - o Serves as instrument for the scoring workshop as it includes all factor résumés which are to be scored by the workshop participants (for further information see below in "during the workshop" or see annex 12)
- ✓ Create a registration and scoring form for the participants of the workshop (see annex 10)
- ✓ Create a scoring table
  - o Serves for the final assessment of the MaaS Readiness Index (for further information see below in "during the workshop" or see annex 4)
  - o Table calculates automatically the MRI result
- ✓ Pre-score indicators that are not existent at the study site (e.g. no bike sharing service is available, thus the score is 1, meaning that the service is not existent or that there is a critical barrier)
  - o The reason for pre-scoring is to reduce the quantity of factors to be scored in the workshop situation

Further pre-arrangements for the workshop

- ✓ Sampling in order to identify suitable workshop participants (scorers)
  - o Need to be experts in the topic and familiar with the study site
  - o Sampling is made by using the four essential questions for sampling as proposed by (Gorden, 1975, pp. 196-197, see chapter 3.3.2)
- ✓ Contact the sampled out experts and arrange a workshop date
  - o Contacts were established through personal recommendations of another researcher
- ✓ Reserve a meeting room
- ✓ Print registration and scoring form
- ✓ Install technical equipment in the meeting room
- ✓ Set up drinks and snacks

During the workshop

The workshop was held on Monday, the 18th of December 2017, in a seminar room of the Faculty of Habitat at the Autonomous University of San Luis Potosí (UASLP). In total, five experts participated in the reunion. Two from the political sector, one from the private sector, one from academia and the author of this investigation (for exact participant details see annex 10). The workshop duration was approximately three hours, form 11am to 2pm. The course of the workshop was oriented on the previously created slide show:

- ✓ Registrations of the participants
  - o Scorers annotate their name, their profession and their experiences in the field of urban and intelligent mobility on the registration and scoring form (see annex 10)
- ✓ Short illustration of the concept of Mobility-as-a-Service by showing a two-minute long explanatory video (see annex 11)
- ✓ Description of the methodology of the workshop
  - o Visual outlining and explanation of the MaaS Readiness Index
  - o Explain the scoring scale, from 1 to 4 (see chapter 2.4)
  - o Explain the main steps of evaluating the MaaS Readiness Index for the study area
  - o Show the participants that the data has been reviewed by an independent auditor (show the signed form)
- ✓ Individual first scoring of the factors based on the factor résumé and on individual expert criterion of the scorers
  - o During this step it is not allowed to enter in discussion
  - o Only questions for clarifications or additional remarks are permitted
  - o Registration and scoring form is used
  - o Factor-for-factor is being presented by showing the respective résumé, further clarified if necessary and directly scored individually by all participants (approximately 1-5 minutes for each factor)
- ✓ Mutual final scoring of factors
  - o Factor-for-factor is revised again
  - o The final scores for each factor are evaluated in the group by comparing, discussing and consensus-building
  - o In case there is no consensus about a score, the minority opinion is annotated in the scoring table and subject to the discussion chapter, the majority opinion is used as final score. As the number of participants is odd, there is always a majority and a minority
  - o The final scores are entered into the previously weighted MRI scoring table (see annex 4) and indicates the resulting MaaS Readiness Index for the study site

At last, the obtained MRI assessment results had to be presented visually in a meaningful result table that facilitated a further discussion (see chapter 5.1.2).

3.4.3 Roadmap synthesis process

In order to analyse the collected and generated data as well as synthesise them into a roadmap towards sustainable Mobility-as-a-Service, a four step strategy was developed.

The first step describes the process of making preliminary theoretical considerations which were deduced from examined literature about MaaS Roadmaps, strategies how to increase preparedness or other integrated and smart mobility action plans. Considering the rather immature state of MaaS development there are not many approaches about this or related topics existent yet. Nonetheless, the few sources that could be identified were regarded as useful practice examples, which facilitated the formulation of an own roadmap approach. In particular, the European MaaS Roadmap 2025 from Eckhardt, et al. (2017) was considered an important source. This was due to the fact that the authors were using, equal to this investigation, a MaaS ecosystem vision as guidance for the roadmap construction.

Step two consists of reviewing the results of the MaaS Readiness assessment for the case city. As already stated in chapter 2.3.3 the index serves not only the purpose of evaluating an areas' preparedness for MaaS but also to demonstrate what and where improvements are required. This is highly relevant for the conception of a roadmap (Goulding, & Kamargianni, 2017). Thus, the inspection of the MRI scoring result table (see table 8 in chapter 5.1.2) permitted to identify which scoring factors of the case city had received MaaS favourable evaluations and which had not. It could be argued that this screening represents a sort of deficit-analysis that is able to indicate the weak-spots in the MaaS ecosystem. In order to achieve the highest possible effectiveness for the subsequent roadmap, the proposed improvements have to focus on low-rated system relevant factors (weighting > 6% and score ≤ 2). This facilitates the creation of necessary preconditions for a sustainable MaaS development.

Step number three describes the analysis of generated material, such as the interviews and the expert survey by means of a qualitative content analysis and descriptive statistics. However, since the data processing of interviews and survey had already been performed to a large extent for the previous research stages only minor analysis adaptations were required. This includes for instance the reassurance that the category catalogue of the QCA does really target a subsequent roadmap formulation.

In the fourth and last step the theoretical considerations as well as the processed data from the mixed methods approach had to be synthesised into a MaaS roadmap. This involved drawing useful interpretations and conclusions from the several analysis tools that allowed to formulate actions and an appropriate time horizon as well as the description of expected transitions. Thereafter, a graphical representation of the roadmap had to be composed (see chapter 5.2).

4 Case study: San Luis Potosí

4.1 General characterisation

The study site of this investigation is the city of San Luis Potosí in Mexico, which represents the capital of the same-named federal state. The core area of the metropolitan zone is composed of the municipalities of San Luis Potosí and Soledad de Graciano Sánchez (see figure 10). Together they account for 1,133,571 inhabitants (41.7% of state pop.) with a population density of 633.9 inh. / km² (INEGI, 2015). The annual growth rates, both in population and in urbanised area fluctuated around 2% per year between 1990 and 2010 (Alva Fuentes, & Martínez, 2017). In line with this general growth trend, the CONAPO (2011) prognoses that the population will further rise to 1.3 million until 2030. Alva Fuentes and Martínez (2017) observed that San Luis Potosí sprawled in an uncontrolled manner also into the surrounding municipalities of Mexquitic de Carmona, Cerro de San Pedro, Zaragoza and Villa de Reyes (see figure 10) Furthermore, they claim that the urban expansion has occurred in a very disperse and fragmented pattern which has reduced the city's overall connectivity.

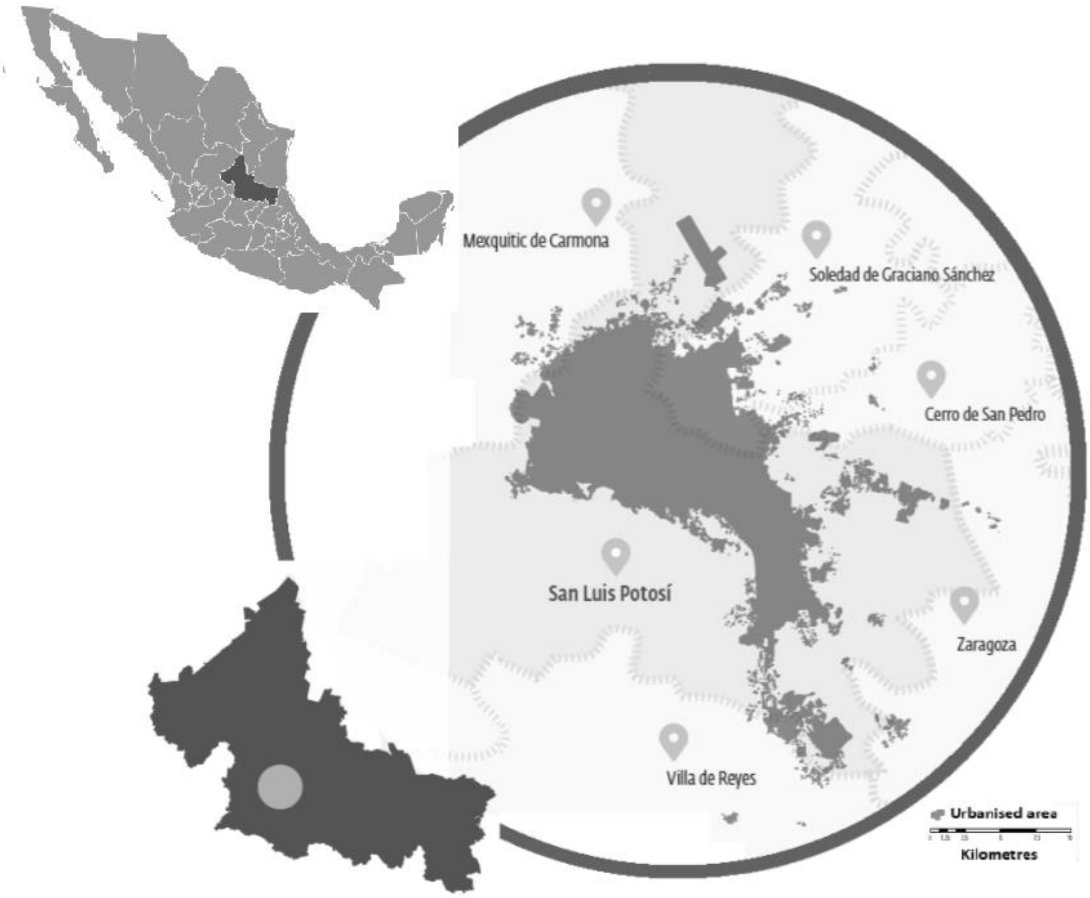

Figure 10. Location of the case city San Luis Potosí, MX (modified from Alva Fuentes, & Martínez, 2017).

The city is located in the valley of Tangamanga on an altitude of 1860m above sea level. It is flanked in the West by the Sierra San Miguelito and in the East by the Sierra de Álvarez. Notwithstanding, the relief of the core city is very even (INEGI, 2010). The climate in San Luis Potosí is semi-arid and temperate with maximum precipitation in summer (Climate classification from Köppen: BSkw[6]). The mean annual precipitation ranges around 300mm to 400mm while the mean annual temperature amounts to 17°C (INEGI, 2010). Green spaces are relatively rare in San Luis Potosí. There are three major parks, the Tangamanga Park one, the Tangamanga Park two and the Morales Park that occupy less than 10% of the densely urbanised area (INEGI, 2010).

San Luis Potosí's historical conformation around mining, agriculture and the railway have turned the city into an important logistic and economic hub between the south and the north of the country (Ayuntamiento de San Luis Potosí, 2016). Nowadays, it amounts for 85% of the states' industrial production which is focussing mainly on car manufacturing and mining (INEGI, 2009). The rate of unemployment is low (2.7%) in comparison with the national level (3.8%) (INEGI, 2009). Nevertheless, the city suffers from great inequalities, which is also highlighted by one of the greatest Gini indexes[7] in Mexico (0.508) (CONEVAL, 2012). Moreover, the Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL, 2012) measured a percentage of 2.9% of inhabitants living in extreme poverty (Income < 978 MXN$ /month) in the municipality of San Luis Potosí. The municipality of Soledad de Graciano Sánchez has an even higher share of people in extreme poverty with 5%.

4.2 Mobility situation

San Luis Potosí represents a classical example of a city with a car-centred paradigm (López Pérez, 2017). Various interviewed mobility experts, such as Alva Fuentes (Personal communication, October 27, 2017) or Moreno Mata (Personal communication, October 27, 2017) claimed that this development has been provoked through automobile oriented transport planning, the trend towards suburbanisation and other elements that can be attributed to the cycle of automobile dependency (Litman, 2017, see chapter 2.1). In accordance with this, López Pérez (2017) additionally highlights the low level of urban connectivity, the road design that disfavours an active mobility behaviour as well as the insufficient and inefficient public transportation system. It consists merely of conventional buses which operate on highly centralised routes (see figure

[6]BS = Steppe-climate, k = winter cold, w = winter dry
[7] The Gini coefficient describes the distribution of income in the population (0 = perfectly equal, 1 = perfectly unequal).

11) and of taxis. However, the taxi service has experienced an increase in capacity and quality, in particular since the introduction of the ride hailing app *Uber* in March 2016 (J. R. Robledo, personal communication, November 23, 2017). *Uber* on the other hand has caused a strong socio-economic impact and an ongoing debate about regulation aspects in the taxi market. In the midst of 2018, a Bus Rapid Transit (BRT) shall be implemented in the city. In its first stage it will focus exclusively on the corridor between the historic centre and the industrial zone but it is intended to be further expanded in the future (J. R. Robledo, personal communication, November 23, 2017). The effectiveness of this measure is being doubted though by multiple interviewed specialists (B. Alva Fuentes, personal communication, October 27, 2017, A. Moreno Mata, personal communication, October 27, 2017, A. López Pérez, personal communication, November 10, 2017). They argue that there has been a lack of transparency and efficient communication in the planning process which have caused various drawbacks, such as unplanned corridor shifts or a class suit by local dwellers. The missing transparency manifests also in the fact that the "Integrated Plan for Sustainable Urban Mobility in San Luis Potosí and Soledad de Graciano Sánchez" (PIMUS) (Gobierno del Estado de San Luis Potosí, 2012) is not open to the public. Furthermore, the interviewees agreed that the actual planning of the BRT is targeting mainly on commuting in the industrial zone instead of aiming to increase connectivity for the whole city and foster multimodal travel behaviour.

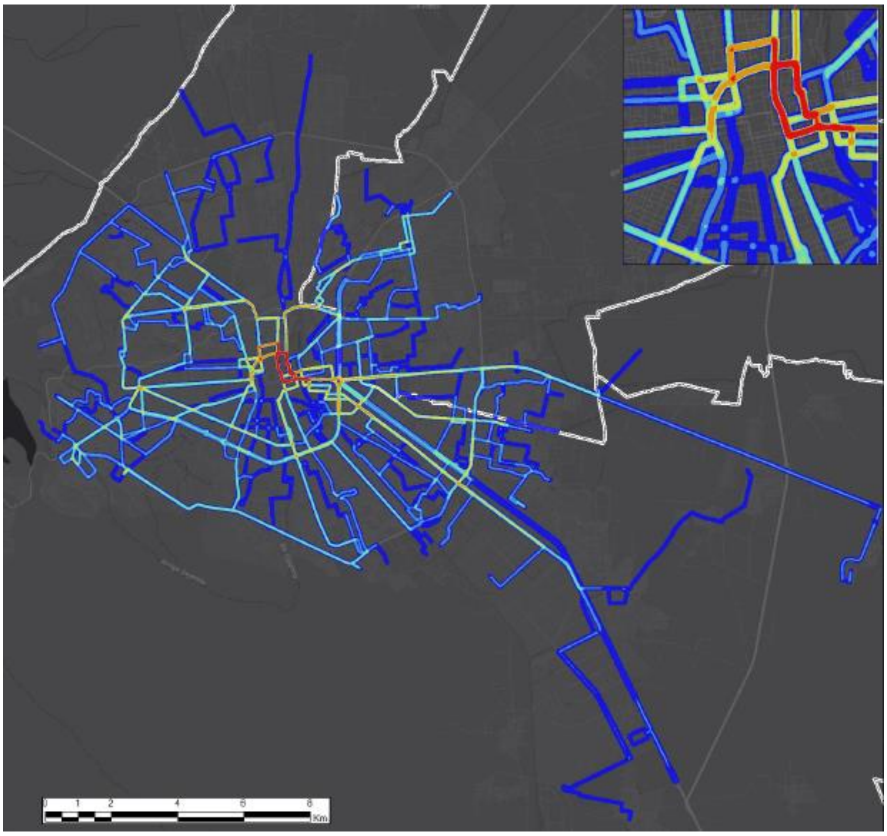

Figure 11. Public transport routes in San Luis Potosí (López Pérez, 2017). Warm-coloured lines indicate high frequency of public transport routes.

UN Habitat (2016) described that the city is facing some major socio-environmental impacts due to the rapid urban expansion. This includes road safety issues, air pollution, excessive land use and other implications. Guerrero Serrano (2010) additionally mentions traffic congestion problems during rush hours and an associated constant increase in origin-destination time. These emerging mobility related effects underscore San Luis Potosí's urgent need for meliorations along the lines of the New Urban Agenda and the Sustainable Development Goals (see chapter 2.1). In order to further reinforce this statement and to justify this investigations' search for solutions a panoramic collection of key characteristics of urban mobility is being outlined in the following.

Figure 12 indicates the current modal split of working commutes in San Luis Potosí. Apart from a non-representative[8] mode share survey from 2006 (Fillis, 2006) there are no previous publications which have studied this phenomenon in the city. However, it can be expected that active and public transport means were used by a higher percentage of people than they are today. Especially when considering the fact that the motorisation rate of San Luis Potosí has increased three-fold between 1990 and 2010, amounting to 423 automobiles per 1,000 inhabitants (SIMBAD, 2010). This number is considerably higher than the average national motorisation rate, being 292 automobiles per 1,000 inhabitants (SIMBAD, 2010).

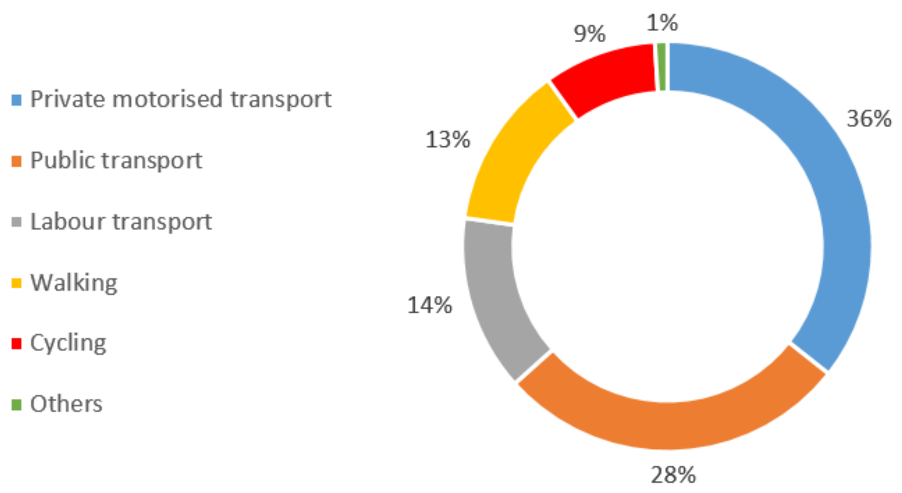

Figure 12. Modal split of working commutes in San Luis Potosí (ITDP, February/2017).

The number of traffic accidents is as well elevated in comparison to similar sized cities (SIMBAD, 2014). It fluctuated between 3000 and 4000 accidents in the years 1997 to 2003 (see figure 13). During 2004 and 2007 accidents became more common, reaching up to 6000 per year. Since 2008 the rate of accidents decreased and stabilised around 3000 (2009-2014). Nevertheless, the total numbers of traffic fatalities stayed quite stable, oscillating between 30 and 60 traffic deaths

[8] Only 256 survey person.

per year (see figure 14). 2014 has been the year with the highest number of fatalities (63). Most of the fatal victims were vulnerable mobility users, such as pedestrians and cyclists (SIMBAD, 2014). Guerrero Serrano (2010) states that most people who use non-motorised transport means are people of lower income, what demonstrates their disadvantage in urban traffic.

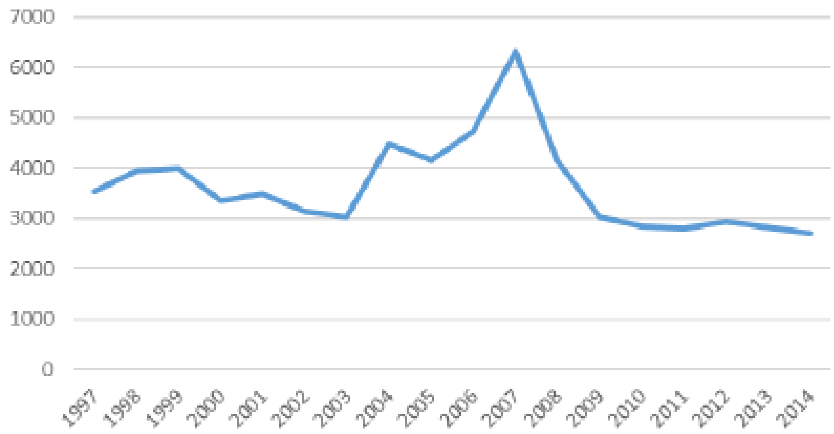

Figure 13. Total traffic accidents in San Luis Potosí (SIMBAD, 2014).

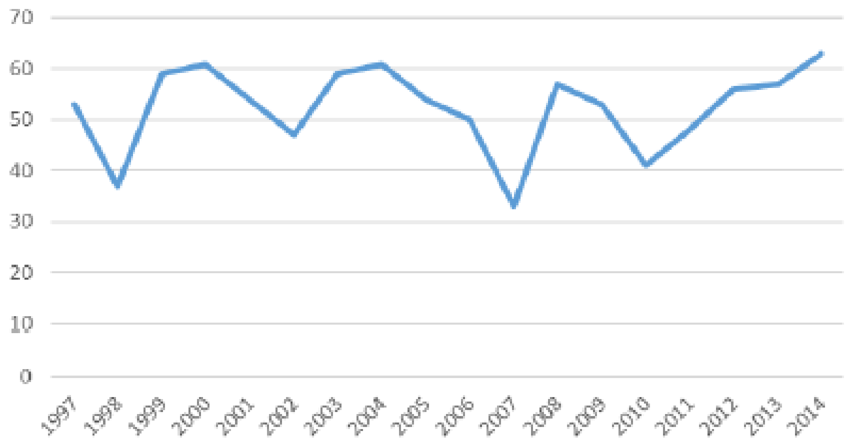

Figure 14. Total traffic fatalities in San Luis Potosí (SIMBAD, 2014).

5 Results and discussion

5.1 MaaS Readiness Index of San Luis Potosí

Before discussing the results of this study one preliminary consideration has to be highlighted: "How and why was the MaaS Readiness Index modified?". Therefore, a transparent depiction of the changes was performed in chapter 5.1.1 which was regarded necessary since the adjustment of the index can have major repercussions on the results. Chapter 5.1.2 focusses then on the outlining and discussion of the assessment results for the case city San Luis Potosí.

5.1.1 Preliminary consideration: Modification of MaaS Readiness Index

As already outlined in chapter 2.3.3 the MaaS Readiness Index (Somers, & Eldaly, 2016) presented some essential shortcomings that made it impossible to apply it identically on this study. Thus, a re-design of the index had to be conducted. The modification of the MaaS Readiness Index was not only targeting on filling the internal methodological gaps but also on including further thematic aspects that were neglected in the original version by Somers and Eldaly (2016). Accordingly, the performed adjustments were deducted from literature sources – in particular from a comparison with other MaaS assessment tools (see chapter 2.3.3) – as well as inducted from generated data, such as interviews and an expert survey about new mobility services (see chapter 3.3.2 and 3.3.3). Table 7 provides an overview by contrasting the before and after the modification of the MaaS Readiness Index. Subsequently, the most important adjustments are being discussed.

The first modification addressed the consideration of all three MRI pillars for the assessment of the index. Although Somers and Eldaly (2016) described the ecosystem triad of supply, demand and regulation in their publication, in practice they focused nearly exclusively on availability aspects. Demand and regulation issues were reduced to a sole mentioning of what should be taken into account without actually assessing them. For the modified MaaS Readiness Index though, these topics needed to be included in order to draw useful sustainability considerations for the objectives of this investigation. The decision to consider all three pillars for the MaaS readiness evaluation can further be reinforced by Kamargianni and Matyas (2017) as well as by Aapaoja et al. (2017) who emphasised the pillar interlinkages' crucial importance for a sustainable MaaS development.

Table 7. Comparison between the original and modified MRI. The text in grey indicates elements that were mentioned but not included to the MRI assessment. Performed changes in the modified MRI are marked with italic letters.

	Original MRI by Somers, Eldaly (2016)	Modified MRI
1st dim.	(1) Availability of transport services (2) Customer demand (3) Government support and regulatory environment	(1) *Availability of transport, mobility and communication services and infrastructure* (2) *Customer demand* (3) *Government support and regulative environment*
2nd dimens.	(1) Active transport; Public transport; Personal transport; Flexible car access; Intercity transport; Additional services (2) Demographical considerations; Attitudinal considerations (3) N/A	(1) Active transport; Public transport; Individual motorised transport; Flexible vehicle access; *Flexible trip access;* Additional services; *ICT services* (2) *Demographical considerations; Attitudinal considerations* (3) N/A
3rd dimensions	(1) 22 third level dimensions; E.g.: For "Public transport" two aspects were regarded (Scheduled public transport services and demand responsive public transport services); The category "Flexible car access" was subdivided into eight topics, such as "car rental" or "peer to peer car parking" (2) N/A (3) N/A	(1) *22 third level dimensions: Minor modifications in thematic categorisation occurred here; Some categories were re-allocated into other third level dimensions or condensed into the same category; This applies particularly for the categories "flexible vehicle access"* (2) N/A (3) N/A
Scoring factors / Indicators	(1) **49 scoring factors:** Similar pattern for each of the 22 third level dimensions: Assessment of factors "Coverage and service density", "Open API for schedule, location, availability" and "Booking API and commercial agreement"; Furthermore, assessment of "mode share" for transport means (2) **Four topics:** General demographics; Specific demographics of potential early adopters; Attitude towards innovative mobility options; Attitude towards car ownership (3) **Four topics:** Level of facilitation and support by government; Subsidies for non-car use; Tax treatment of mobility in salary packages; Legislation and regulation including privacy, liability and risk • **In total: 49 scoring factors**	*(1)* ***61 scoring factors:*** *Similar pattern for each of the 22 third level dimensions: Assessment of scoring factors "Coverage and service density (of mobile app)", "Service functions"; "API's"; Furthermore, assessment of "mode shares" for transport means* *(2)* **Four scoring factors:** General demographics; Specific demographics of potential early adopters; Attitude towards new mobility services; Attitude towards vehicle ownership *(3)* **Four scoring factors:** Level of political facilitation; *Public infrastructure investments; Level of stakeholder collaboration;* Data security, privacy and liability • **In total: 69 scoring factors**
Data acquis	• Interviews • Literature & database review • Questionnaires	• Interviews • Literature & database review • *Expert survey about potential of new mobility services in the case city* • *Individual questionnaire for local transport authority of the case city*
Scoring chart	0 = no service or critical barrier exists to service being used for MaaS 1 = some usefulness for MaaS, but below what would be desirable 2 = supportive of MaaS but some gaps exist 3 = fully supportive of MaaS, the best that can reasonably be hoped for	*1* = no service or there is a critical barrier to be useful for MaaS *2* = some usefulness for MaaS, but below what would be desirable *3* = supportive of MaaS, but there are some gaps *4* = totally supportive of MaaS
Scoring process	• Incomplete description of previous data analysis • Sole mentioning of a four step scoring process; Score assignment involved converting a qualitative assessment into a number: Step 1: For each factor, a descriptive text is written explaining the situation in that city/region/country. Step 2: A second person reviews the descriptive text to confirm accuracy of statements. Step 3: At least two people separately score each factor, based on the agreed descriptive text. Step 4: The scorers reconcile individual scores to determine an agreed score for each factor.	Step 1: Condensation of acquired and analysed data into well-grounded scoring factors résumés that represent the current situation in the case site Step 2: Verification of data accuracy of factor résumé contents through an independent auditor Step 3: Scoring workshop with mobility experts to jointly evaluate the MRI a. At least two specialists score each factor separately, according to their own expert criterion and to the provisioned information in the factor résumés b. The scorers reconcile individual scores to determine an agreed score for each factor

Further identified gaps were that the original MRI did not include the availability and condition of infrastructure. Moreover, there was no consideration of communication aspects, such as the penetration and usage of mobile devices in the population, or the presence of Wi-Fi and mobile internet. Since MaaS is not viable without ICT and because most authors and interviewees agree that ICT and infrastructure conditions have to be considered for developing Mobility-as-a-Service (Aapaoja, et al., 2017, Kamargianni, & Matyas, 2017, Goulding, 2017, Jittrapirom et al., 2017), these aspects were additionally included to the supply side dimension. According to the applied changes, the first pillar was renamed in "availability of transport, mobility and communication services and infrastructure".

The index received some additional minor adjustments in the thematic categorisation. These changes include the re-allocation, condensation and adding of topics. While the original MRI considered 49 scoring factors, the updated version counts 69. Respectively four, rather generic scoring factors pertain to the demand and regulation pillar (see figure 8 in chapter 2.4). The supply side dimension on the other hand consists of 61 very detailed scoring factors. The strong compartmentalisation of the supply pillar occurs primarily due to two reasons: Because of the inclusion of newly emerging MaaS-relevant services, such as "individual on-demand transport", "shared intraurban trips" or "travel planner apps" and; because of the need for a very detailed evaluation of each service. This in depth assessment of services is what makes the index particularly useful for the construction of a MaaS Roadmap since it permits to identify also small-scaled weak-spots in the MaaS ecosystem. Certainly, the customer demand and regulation aspects are evolving as well. However, the factors to be taken into account were not considered to be as variable. Thus, a further partitioning did not appear necessary for them.

One particularly striking issue that Somers and Eldaly (2016) did not regard but that had to be addressed in the modified MRI was the aggregation of the scoring results. Their publication leaves unstated whether the graded factors were averaged, weighted, used for the identification of preconditioning issues or any other sort of processing (Somers, & Eldaly, 2016).

Since taking the average of scores would have led to extreme distortions this method could rapidly be excluded for the re-designed MRI. This would have signified that doubtlessly important factors like the "public transport mode share" would range on the same level as the "coverage and service density of rental vehicles", for instance. Instead, a weighted index appeared as the most appropriate solution, because most of the assessed indicators possess different levels of relevance for the general MaaS readiness (Goulding, 2017). This performed measure is in line with the resembling MaaS Maturity Index which represents a weighted index as well. For reasons of the before mentioned inaccessibility to the exact MMI description (see chapter 2.3.3), the weighting could not just be adopted (and adjusted) to the modified MRI. Hence, a normative weighting method, the "weight determination by expert rating" was applied (Döring, & Bortz, p. 282). It is conducted by specialists with broad expert knowledge to professionally appraise the relative importance of each indicator (Döring, & Bortz, p. 282). In case of this investigation, the weighting was determined through the author himself whose expert judgment grounded on the findings from the previously mentioned deductive as well as inductive considerations. Ultimately though, this normatively weighted, interval-scaled index remains highly subjective since it draws on the opinion of solely one expert. In order to achieve a more objective weighting other experts need to confirm the accuracy and/ or collaborate in the weighting process (Döring, & Bortz, p. 282).

The weight determination occurred at all four index levels (concentric circles) which have been outlined previously in figure 8 (see chapter 2.4). The main principle of the weight determination was the expected systemic effect of one element. In line with this, factors that were appraised with a weight of > 6% were defined as system relevant since their scoring result could highly influence the overall readiness rating. This included respectively three scoring factors of the demand and regulation pillar as well as three second level dimensions of the supply area[9]. The summed up weight of these nine factors represents 84.12%. This overwhelming importance highlights that the MaaS Roadmap should target principally those nine elements since their improvements can rapidly increase the level of MaaS readiness. In the following, some weighting examples are being depicted:

The supply, demand and regulation pillar represent mutually dependent elements in the MaaS ecosystem where the change of one aspect can have drawbacks on others. Since this viewpoint can be additionally confirmed with references to Aapaoja et al. (2017) or Kamargianni and Matyas (2017) who assess the interrelation similarly, the author determined the weight for each first level dimension equally with 33.33%.

The high weighting of ICT services (11.67%) can be reinforced with references to Burrows, Bradburn and Cohen (2017), Meyer and Shaheen (2017) or Jittrapirom et al. (2017) that claim their crucial systemic importance for MaaS to be feasible. Public and active transport are as well considered of significant relevance. Especially when envisioning a sustainable approach towards MaaS that targets the fostering of green travel choices and means as well as a broad service integration (UITP, April/2016, Wefering, et al., 2013).

[9] Since the first pillar is too partitioned it appeared more practical to determine factors from the overarching second level dimensions as system relevant. This permitted also a better contrasting to the system relevant factors of the other two thematic pillars.

Further examples are the demographic and attitudinal considerations. They have been appraised with a high weighting because they represent elements of the sociocultural and other megatrends which have strong implications on individual travel behaviour (see chapter 2.1). In particular, the general demography was appraised with a very high weighting. This can be explained with the fact that it includes various elementary aspects, such as the number of inhabitants, the population growth, the population density, the urbanisation rate, data about urban sprawl, among many others. All these considerations are finally related to people and their behaviours. And since the demography is also regarded as the "study of changes in the structure of human populations" (Oxford, 2017) it has immense implications on the mobility of a city, which is why it was weighted so high.

5.1.2 Assessment of MaaS Readiness level

The MaaS readiness analysis for San Luis Potosí resulted in an **overall score of 2.03** (see table 8). This rating represents the aggregated value of all 69 assessed factors. According to the scoring scale from 1 (least ready for MaaS) to 4 (most ready for MaaS), this signifies that the case site presents "some usefulness for MaaS, but below what would be desirable". In order to present the assessment outcomes as comprehensible as possible the description and a subsequent discussion have been oriented on the triad structure of the MaaS Readiness Index. This implies an initial contrasting of the three thematic pillars (supply, demand and regulation) and an exemplary consideration of more specific categories. The aggregated scores for the three MRI topics supply, demand and regulation lie roughly between 1.5 and 2.5 (see figure 15). The dimension "customer demand" was rated highest with a value of 2.50. The second best score was accredited to "availability of transport, mobility and communication services and infrastructure" with 2.02. With only 1.57, the pillar of "government support and regulatory environment" received the lowest grading.

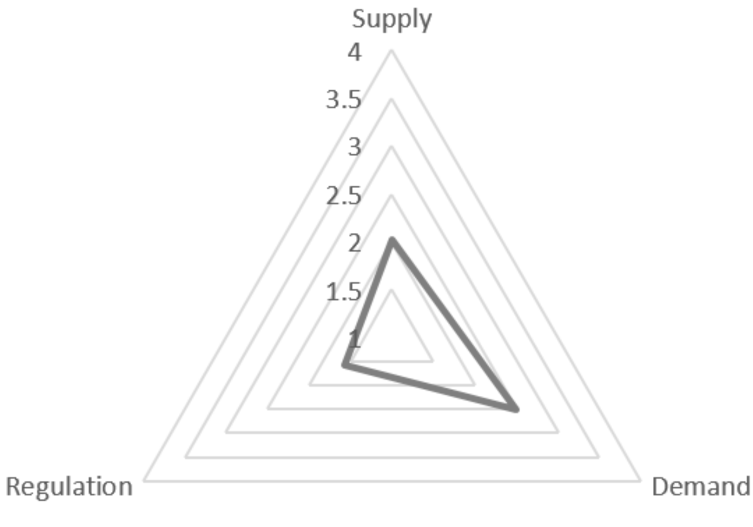

Figure 15. Spider diagram of San Luis Potosí's MaaS readiness (1 = least ready for MaaS - 4 = most ready for MaaS).

Table 8. Result table of MRI assessment of San Luis Potosí (Colour coded scores: 1 = red, 2 = orange, 3 = light green, 4 = dark green). System relevant factors are marked with italic letters.

1st pillar - Availability of transport, mobility and communication services and infrastructure (33.33%).

Second level	Second level score	Third level	Third level score	Scoring factors	Weight-ings of scoring factors	Score
Active transport	1.60	Walking	2.00	Modal split of "walking"	1.33%	
				Pedestrian infrastructure	1.33%	
		Cycling	1.50	Modal split of "bicycle"	1.33%	
				Cycling infrastructure	1.33%	
		Bike share	1.00	Coverage and service density	0.44%	
				Service functions	0.44%	
				API's	0.44%	
Public transport	1.93	Public transport services	2.50	Modal split of "public transport"	1.43%	
				Public transport infrastructure	1.43%	
		Travel planner	1.67	Coverage and service density	0.95%	
				Service functions	0.95%	
				API's	0.95%	
		On-demand public transport	1.00	Coverage and service density	0.32%	
				Service functions	0.32%	
				API's	0.32%	
Individual motorised transport	2.42	Personal vehicle	2.50	Modal split of "personal vehicle"	0.33%	
				Infrastructure of vehicular transport	0.33%	
		Taxi	1.75	Coverage and service density	0.17%	
				Coverage and service density of mobile app	0.17%	
				Functions of mobile service	0.17%	
				API's	0.17%	
		Individual on-demand transport	3.00	Coverage and service density	0.22%	
				Service functions	0.22%	
				API's	0.22%	
Flexible vehicle access	1.63	Rental vehicles	2.50	Coverage and service density	0.11%	
				Coverage and service density of mobile app	0.11%	
				Functions of mobile service	0.11%	
				API's	0.11%	
		Shared vehicles	1.00	Coverage and service density	0.44%	
				Service functions	0.44%	
				API's	0.44%	
		Parking	1.33	Coverage and service density	0.30%	
				Service functions	0.30%	
				API's	0.30%	
Flexible trip access	1.61	Private collective on-demand transport	1.00	Coverage and service density	0.30%	
				Service functions	0.30%	
				API's	0.30%	
		Shared intraurban trips	1.67	Coverage and service density	0.30%	
				Service functions	0.30%	
				API's	0.30%	
		Shared interurban trips	2.33	Coverage and service density	0.15%	
				Service functions	0.15%	
				API's	0.15%	
		Other interurban transport services	2.00	Coverage and service density	0.11%	
				Coverage and service density of mobile app	0.11%	
				Functions of mobile service	0.11%	
				API's	0.11%	
Additional services	1.44	Food delivery services	1.67	Coverage and service density	0.11%	
				Service functions	0.11%	
				API's	0.11%	
		Grocery delivery services	1.67	Coverage and service density	0.11%	
				Service functions	0.11%	
				API's	0.11%	
		Logistic services	1.00	Coverage and service density	0.11%	
				Service functions	0.11%	
				API's	0.11%	
ICT services	2.48	Mobile devices	3.00	Availability of mobile devices	5.55%	
		Internet	2.00	Coverage and service density of Wi-Fi	2.78%	
				Coverage and service density of mobile internet	2.78%	
		Contactless payments	2.00	Coverage and service density	0.28%	
				API's	0.28%	

2.02

Continuation of previous sub table:
2nd pillar - Customer demand (33.33%).

Second level	Second level score	Scoring factors	Weightings of scoring factors	Score
Demographical considerations	3.00	*General Demography of case city*	13.89%	
		Specific demographics of potential early adopters	2.78%	
Attitudinal considerations	2.00	*Attitude towards new mobility services*	8.33%	
		Attitude towards car ownership	8.33%	

2.50

Continuation of previous sub table:
3rd pillar – Gov. support & regulatory environment (33.33%).

Scoring factors	Weightings of scoring factors	Score
Level of political facilitation	9.52%	
Public infrastructure investments	9.52%	
Level of stakeholder collaboration	9.52%	
Data security, privacy and liability	4.76%	

1.57

MRI of San Luis Potosí = 2.03

Table 8 outlines the respective evaluation results graphically. With the purpose to facilitate a comparison, the illustration has been divided into three sub tables, each of which represent one MRI pillar. The different coloration in the "score" column(s) displays the colour coded ratings that were obtained from the expert workshop (1 = red, 2 = orange, 3 light green, 4 = dark green[10]). Most factors received scorings of "1" or "2". Besides, a variety of highly weighted indicators were also graded with "3". However, the best possible grade of "4" was not assigned to any category. The relative weight of each scoring factor can be rapidly screened by regarding the different row heights of the "score" column(s). The thicker the row of one scoring factor, the more weight was appraised to it. Since all three MRI pillars were weighted equally with 33.33% the combined row heights of each sub table are identical. When regarding the individual categories though, it becomes apparent that the weight of factors was appraised highly variable, in particular for the "availability" pillar (see chapter 5.1.1). It has to be mentioned that the individual factor scorings can also be aggregated into smaller segments as desired. For instance, if only the MaaS readiness level of "active transport" shall be highlighted it is merely necessary to consider the factors that pertain to this topic (see column "second level score" in table 8). In the following, the results of the scoring workshop are being discussed with a focus on system relevant MaaS elements from the different MRI pillars.

When regarding the *"ICT services"* (weight = 11.67%, overall score = 2.48) more closely, it constitutes of three third level factors and five scoring factors (see table 8). The table shows that three of the five scoring factors have a somewhat elevated weight for the MRI. These are, the availability of mobile devices (5.55%) as well as the coverage and density of Wi-Fi and mobile internet (both 2.78%). The best rating of an underlying scoring factor was accredited to the "availability of mobile devices" which received a "3" as grading, meaning that it is "supportive for MaaS, although some gaps do still exist". It was evaluated that high since 81.1% of the inhabitants of the case city already own a smartphone and because of a clear tendency towards an increasing quantity of mobile devices can be observed (INEGI, 2016). The other scoring factors were all scored with "2" each, but since the "availability of mobile devices" has the highest weight it lifts the combined rating of the "ICT services" to 2.48.

Besides this absolutely fundamental aspect of Information and Communication Technologies, *"active transport"* (weight = 6.67%, overall score = 1.60) was regarded as well as crucial for an adequate MaaS development. Particularly for Mobility-as-a-Service that tends strongly towards sustainability. The indicators with the highest weightings were the modal split of both walking

[10] The grade "4" was not assigned to any category.

and cycling, as well as the pedestrian and cycling infrastructure. Both mode shares were evaluated with a "2", although there was some disagreement in the expert workshop, whether the walking share could not also have been graded with a "3". This is to explain with the fact that the walking mode share is considerably high as already portrayed in chapter 4.2. In recent years though, the score evaluators have observed an ongoing tendency towards less travel by foot which led to this scoring result.

Another key component of the first MRI dimension is *"public transport"* (global weight = 6.67%, overall score = 1.93). Without a functional and integrated public transportation system MaaS cannot be implemented in a sustainable way (UITP, 2017). Particularly, because two key objectives of MaaS would not be possible to achieve. The reduction of motorised vehicle ownership and use. The category is further subdivided into "public transport services" (global weight = 2.86%), "travel planner" (global weight 2.86%) and "on-demand public transport" (global weight = 0.95%).

The indicator "modal split of public transport" was evaluated with a score of "3", since the number of users is considerably high. The public transport infrastructure received a score of "2" as it is regarded as rather dysfunctional, centralised and consisting only of busses instead of a variety of mass transit options. Nonetheless, it offers a certain degree of connectivity to the inhabitants which justifies the grading. Considering the travel planner, there is one principal mobile application already in place at San Luis Potosí. The app is called "Moovit" and offers door-to-door journey planning for public transport and bicycles. The implementation of this service was supported by the local transport authority, the "Secretaría de Comunicaciones y Transporte" (SCT Estatal). It covers the complete urbanised area of the case city and can indicate different routing options and navigation for both modes. Moreover, Moovit can display the estimated travel time and sends a notification when to dismount a bus in order to board the next one. Nevertheless, there have been identified various gaps. For instance, it does not indicate prices as well as real time locations of PT units. Furthermore, there are no notifications about the probable arrival time or any sort of disruptions, like delays. But most importantly regarding MaaS readiness, is that the travel planner does not offer any payment service and that the API options in order to interconnect applications, data and devices remain largely unused. The last second level category is about on-demand public transport, also called demand-responsive transport. The terms describe an "advanced and user-oriented type of public transport, that is characterised through flexible routing of small- or medium-sized vehicles operating in shared-ride modes between pick-up and drop-off locations according to passenger's needs" (Vega Barbero, July/2014). It is specifically designed for low-density areas and is operated by public as well as private stakeholders. But since in San Luis Potosí no such service exists it received the lowest grade of "1" for all three underlying indicators.

The second pillar of the MRI, the customer demand, was evaluated with an overall score of 2.50. It constitutes only of four scoring factors that were divided into two second level categories. The two thematic topics for evaluating the customer demand were "demographical considerations" as well as "attitudinal considerations".

The factor *"general demography"* has the highest weighting of all regarded aspects. It accounts for 13.89% of the MaaS Readiness Index. Hence, it represents a crucial element for the development of MaaS since its rating can heavily influence the overall result. This indicator was weighted so high as it includes various elementary aspects, such as the number of inhabitants, the population growth, the population density, the urbanisation rate, data about urban sprawl, among others. All these information are finally related to people and their behaviours. Demography is regarded as the changing structure of human populations and it has immense drawbacks on the mobility of a city, which is why it was weighted so high. In the scoring workshop this factor was evaluated with "3" for San Luis Potosí, which describes rather favourable in situ conditions.

In the *"attitudinal considerations"* two more elementary aspects were regarded. The attitude of the inhabitants towards new mobility services and their attitude towards vehicle ownership. Both factors were scored with "2". Particularly the expert survey helped to obtain data about these considerations. The results showed that the level of openness towards changing the travel behaviour is considerably low.

At this point it has to be mentioned that one weakness of the index is the imbalance in the quantity of scoring factors. The fact that the demand and regulation pillar counts only with very few but highly weighted assessment points leads to a disproportional higher importance than the scoring factors of the supply pillar. Thus, the overall assessment result can be influenced rather strongly through factors of the demand and regulation pillar. The supply pillar on the other hand is not as sensitive to an eventual distortion of results since it consists of multiple small scaled scoring factors. Another critique on the index is that it regards solely the status quo of urban mobility. This means that past developments or planned measures that might influence the MaaS readiness level are not subject to evaluation. However, considering the large amount of required data the focus on the current situation appears reasonable.

5.2 MaaS Roadmap for San Luis Potosí

In order to propose a sustainability envisioning MaaS Roadmap for San Luis Potosí further data analysis is needed. The investigator was not able to conclude the required research steps in the limited amount of time. However, at this point shall be stated that this research was aiming on a product, similar to the European MaaS Roadmap which was proposed by Eckhardt et al. (2017) (see figure 16).

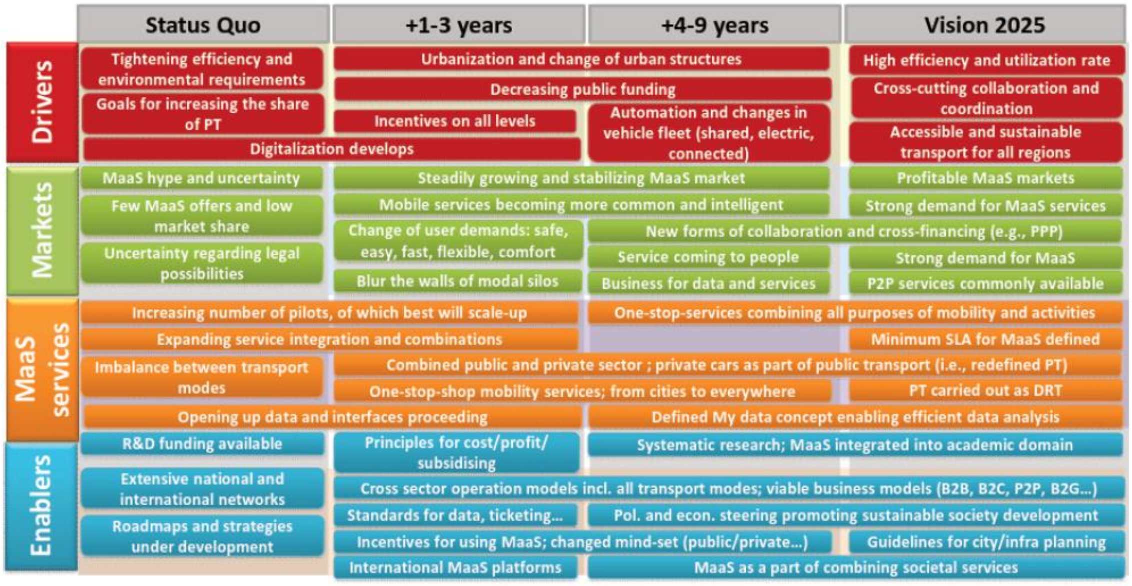

Figure 16. European MaaS Roadmap (Eckhardt, et al., 2016).

6 Conclusions and outlook

This research permitted to draw the following conclusions and outlooks:

- In response to the first research question it can be stated that the current urban mobility situation in San Luis Potosí is disperse, disconnected, car-dependent and lacks of an efficient public transportation system.
- The preconditions for MaaS to be feasible in San Luis Potosí are not present. The main constraints are the unfavourable regulatory environment, the lack of public transport integration and the weakly developed digital environment. Thus, in order to answer the second research question, San Luis Potosí is not ready for Mobility-as-a-Service but presents some useful elements. This includes for instance, the high penetration and usage of internet and mobile devices as well as a broad demand base.
- The third research question remains largely unanswered. However, in order to improve the MaaS readiness level the integration of transport and mobility services has to be targeted. Furthermore, multiple stakeholders need to be involved in the planning of the mobility system. In particular, the city and the regional authority. The role of the public sector is to provide favourable operating conditions. The private sector has the responsibility for innovations and service development. The academia should identify best practice examples and conduct impact assessments. And users need to be involved more actively in mobility planning. Besides, a MaaS Roadmap needs to be understood as a part of an overarching Sustainable Urban Mobility Plan (SUMP).
- The modified MaaS Readiness Index is a useful tool to appraise the level of MaaS maturity. However, it requires further refinement. In particular, regarding the weight determination and the categorisation of the demand and regulation pillar.
- A crucial research limitation was the fact that there is a lack of expert knowledge about MaaS, especially in the local context of San Luis Potosí.
- Future research is required to gain insights in potential impacts of new mobility services. Especially regarding eventual drawbacks for the traditional public transportation system or changes in peoples' travel behaviour. Furthermore, a greater understanding of the MaaS operator role has to be achieved. Alternative research scopes could be the assessment of individual actors' MaaS readiness or the assessment of specific city areas.
- Innovations may change San Luis Potosí's transport system but it is unlikely that they will change the mobility paradigm. However, the future introduction of a BRT or the rise of new mobility services could foster increased multimodality. Regarding San Luis Potosí's assessed mobility characteristics, it presents a certain potential for further shared mobility options.

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Annex

A collection of all annexes can be accessed through this link:

https://www.dropbox.com/sh/kr5iyyzaptli2yi/AABt8nD9vPjuKe9Ns68dmaaFa?dl=0

Annex 5. Expert survey about new mobility services.

Encuesta sobre nuevos servicios de movilidad en San Luis Potosí

La movilidad urbana, como muchos otros aspectos de la vida cotidiana en una ciudad, han tenido un cambio radical debido a diferentes tendencias en nuestra sociedad, tal como es el uso creciente de tecnologías de la información y la comunicación. El fácil acceso y rapidez mediante el uso de dispositivos móviles plantea transformaciones en la manera como nos desplazamos.

La Facultad de Ingeniería y la Facultad del Habitat de la UASLP realizan un estudio sobre la movilidad de San Luis Potosí. Particularmente se elabora una tesis de Maestría en Ciencias Ambientales que analiza los potenciales e impactos de nuevos servicios de movilidad (e.g. Uber, Moovit, etc.) en San Luis Potosí. Además, se busca identificar qué características presentes en la capital potosina son favorables o no para el uso de estas tecnologías.

Está invitado a participar en esta encuesta. Solo tomará aproximadamente 15 minutos. Esta encuesta es anónima y los datos obtenidos solo se utilizarán con fines académicos. Si tiene alguna duda, puede ponerse en contacto con dimitrithanos@gmail.com.

¡Muchas gracias por su tiempo y apoyo!

*Obligatorio

FACULTAD DE INGENIERÍA — FACULTAD DEL HABITAT — UASLP Universidad Autónoma de San Luis Potosí

Información personal

1. ¿Desde hace cuánto tiempo conoce San Luis Potosí? *
   Marca solo un óvalo.
   - No conozco San Luis Potosí
   - Menos de 1 año
   - 1 - 5 años
   - 5 - 10 años
   - 10 - 20 años
   - Más de 20 años

2. ¿Qué edad tiene? *
   Marca solo un óvalo.
   - ≤ 20 años
   - 21 - 30 años
   - 31 - 40 años
   - 41 - 50 años
   - 51 - 60 años
   - 61 - 70 años
   - ≥ 71 años

3. ¿En qué tipo de organización / empresa trabaja? *
   Selecciona todas las opciones que correspondan.
   - Gobierno Municipal (e.g. IMPLAN)
   - Gobierno Estatal (e.g. SCT Estatal)
   - Gobierno Federal (e.g. SCT Federal)
   - Insitución financiera (e.g. Secretaria de Finanzas)
   - Inversionistas privados
   - Empresa del transporte público
   - Empresa automotriz / del transporte
   - Empresa de tecnología y comunicación
   - Empresa de servicios de movilidad
   - Academia o instituto de investigación
   - Organización no gubernamental / civil
   - Consultoría (e.g. de movilidad o de planeación urbana)
   - Compañía de seguros
   - Otros: ____

4. ¿Cómo se llama la organización / empresa donde trabaja? *

5. ¿Cuál es su posición (cargo) en la organización / empresa? *

6. ¿Es usted un tomador de decisiones en su empresa / organización? *
   Marca solo un óvalo.
   - Sí
   - No

7. ¿De cuánto son sus ingresos netos al mes? *
   Marca solo un óvalo.
   - Menos de 5.000 $ MXN
   - 5.000 - 10.000 $ MXN
   - 10.000 - 20.000 $ MXN
   - 20.000 - 30.000 $ MXN
   - 30.000 - 50.000 $ MXN
   - 50.000 - 100.000 $ MXN
   - Más de 100.000 $ MXN
   - Prefiero no responder / No lo sé

8. ¿Cuál es su nivel educativo más alto alcanzado? *
   Marca solo un óvalo.
   - Sin calificación formal
   - Bachillerato
   - Técnico/a o tecnólogo/a
   - Licenciado/a
   - Maestro/a
   - Doctor/a

Funciones de nuevos servicios de movilidad

9. Los nuevos servicios de movilidad con base en dispositivos móviles ofrecen varias funciones. Según usted ¿cuáles son las más relevantes para promover soluciones sostenibles en San Luis Potosí? *
   Elija un máximo de 3 opciones.
   Selecciona todas las opciones que correspondan.
   - Planificación de viajes, integrando diferentes transportes y servicios de movilidad
   - Servicio de pago mediante un dispositivo móvil (e.g. por viaje o mensualidad)
   - Transparencia en el cálculo de la tarifa
   - Información en tiempo real (alerta de disrupciones)
   - Indicación de disponibilidad y ubicación (e.g. de estacionamientos o de automóviles compartidos)
   - Personalización del servicio
   - Servicio de atención al cliente
   - Ofertas especiales
   - Sistema de bonificación
   - Servicio de entrega (e.g. de compras, alimentos)
   - Otros: ____

Relevancia de nuevos servicios de movilidad para San Luis Potosí

10. ¿Qué nuevos servicios de movilidad con base en dispositivos móviles son los más relevantes para promover soluciones sostenibles en San Luis Potosí? Servicios para.. *
    Entre paréntesis se mencionan explicaciones del tipo de servicio y ejemplos de diferentes aplicaciones para dispositivos móviles. Elija un máximo de 5 opciones.
    Selecciona todas las opciones que correspondan.
    - ...planear viajes, integrando diferentes modos de transporte (e.g. Moovit, Google Maps)
    - ...integrar la planeación y el pago de viajes de diferentes transportes y servicios de movilidad disponibles - "Mobility as a Service"
    - ...taxis oficiales (e.g. StopTaxi, MyTaxi)
    - ...transporte a pedido "tipo" taxi (e.g. Uber)
    - ...transporte colectivo a pedido (e.g. UberPOOL, Via; haciendo coincidir a varios pasajeros con un vehiculo disponible)
    - ...compartir bicicletas - "Bikesharing" (e.g. Ecobici)
    - ...compartir automóviles - "Carsharing"
    - ...compartir automóviles privados (propietarios de automóviles privados ponen a disposición sus vehiculos para alquiler por periodos cortos de tiempo)
    - ...viajes compartidos intra- e interurbanos (e.g. Split, BlaBlaCar)
    - ...viajes interurbanos en autobuses y transporte aéreo (e.g. aplicaciones de Primera Plus, Volaris)
    - ...indicar disponibilidad de estacionamientos para automóviles
    - ...compartir estacionamientos privados (propietarios de estacionamientos de automóviles ponen a disposición sus estacionamientos para alquiler por periodos cortos de tiempo)
    - ...entrega de alimentos y de compras en general (e.g. UberEATS)
    - Otros: ____

Áreas geográficas

11. **¿Qué áreas geográficas son las más relevantes para implementar nuevos servicios de movilidad?** *

Elija un máximo de 3 opciones.
Selecciona todas las opciones que correspondan.

- ☐ Municipios urbanos (San Luis Potosí y Soledad de Graciano Sánchez)
- ☐ Municipios suburbanos (Cerro de San Pedro, Zaragoza, Villa de Reyes y Mexquitic de Carmona)
- ☐ Municipios rurales (Ahualulco, Armadillo de los Infante, Santa María del Río, Tierra Nueva y Villa de Arriaga)
- ☐ Nivel estatal
- ☐ Nivel nacional
- ☐ Nivel trans-nacional
- ☐ Otros: ____________

Impactos de nuevos servicios de movilidad

Suponiendo que los nuevos servicios de movilidad serán implementados e integrados a gran escala en San Luis Potosí ¿cómo cree que se verán afectados los siguientes aspectos...

12. **...a nivel individual / del usuario?** *

Marca solo un óvalo por fila.

	Alta disminución	Disminución	Sin impacto	Aumento	Alto aumento	Sin opinión
Número de proprietarios de automóviles privados						
Uso de automóviles privados						
Uso del transporte público						
Uso de modos activos (caminar, andar en bicicleta)						
Uso de combinaciones de diferentes transportes						
Uso de servicios de información electrónica (e.g. del tráfico)						
Uso de métodos de pago electrónico						
Costo total de viajes para el individuo						
Número de viajes realizados						
Estrés asociado con los viajes						
Satisfacción general con el sistema de transporte						

13. **...a nivel socio-ambiental?** *

Marca solo un óvalo por fila.

	Alta disminución	Disminución	Sin impacto	Aumento	Alto aumento	Sin opinión
Número de estacionamientos						
Congestión del tráfico						
Seguridad del tráfico						
Emisiones (CO2, NOx, etc.)						
Salud pública						
Acceso a soluciones de movilidad						
Número promedio de personas por vehículo						
Tiempo de traslado						

14. **...a nivel político y empresarial / organizacional?** *

Marca solo un óvalo por fila.

	Alta disminución	Disminución	Sin impacto	Aumento	Alto aumento	Sin opinión
Oportunidades para negocios						
Diversidad socio-económica de los usuarios						
Compartir datos e informaciones entre actores						
Alianzas entre actores (e.g. asociaciones de público-privado)						

15. **¿Prevé algún otro impacto para San Luis Potosí, tanto negativo como positivo? En caso afirmativo, por favor especifique.**

Actores

16. **¿Qué tan importante es involucrar a los siguientes actores para implementar nuevos servicios de movilidad en San Luis Potosí?** *

Marca solo un óvalo por fila.

	Nada importante	Poco importante	Importante	Fundamental	Sin opinión
Población (usuarios)					
Gobierno Municipal (e.g. IMPLAN)					
Gobierno Estatal (e.g. SCT Estatal)					
Gobierno Federal (e.g. SCT Federal)					
Insituciones financieras (e.g. Secretaría de Finanzas)					
Inversionistas privados					
Empresas del transportes público					
Empresas automotrices y del transporte					
Empresas de tecnología y comunicación					
Proveedores de servicios de movilidad					
Academia e institutos de investigación					
Organizaciones no gubernamentales / civiles					
Consultorías (e.g. de movilidad o de planeación urbana)					
Compañías de seguros					

17. **Otros actores y sus niveles de importancia:**

18. **En esta sección queremos conocer su opinión sobre los roles que diferentes actores podrían tener en el escenario de una introducción amplia de nuevos servicios de movilidad en San Luis Potosí.**

Elija un máximo de tres actores por columna.
Selecciona todas las opciones que correspondan.

	Bene-ficiados principales	Sub-representados principales	Promotores principales	Obstructores principales	Colabora-dores principales	Respon-sables principales
Población (usuarios)	☐	☐	☐	☐	☐	☐
Gobierno Municipal (e.g. IMPLAN)	☐	☐	☐	☐	☐	☐
Gobierno Estatal (e.g. SCT Estatal)	☐	☐	☐	☐	☐	☐
Gobierno Federal (e.g. SCT Federal)	☐	☐	☐	☐	☐	☐
Insituciones financieras (e.g. Secretaría de Finanzas)	☐	☐	☐	☐	☐	☐
Inversionistas privados	☐	☐	☐	☐	☐	☐
Empresas del transportes público	☐	☐	☐	☐	☐	☐
Empresas automotrices y del transporte	☐	☐	☐	☐	☐	☐
Empresas de tecnología y comunicación	☐	☐	☐	☐	☐	☐
Proveedores de servicios de movilidad	☐	☐	☐	☐	☐	☐
Academia e institutos de investigación	☐	☐	☐	☐	☐	☐
Organizaciones no gubernamentales / civiles	☐	☐	☐	☐	☐	☐
Consultorías (e.g. de movilidad o de planeación urbana)	☐	☐	☐	☐	☐	☐
Compañías de seguros	☐	☐	☐	☐	☐	☐

19. **Otros actores:**

Aspectos fundamentales para una implementación de nuevos servicios de movilidad

20. **¿Qué tan importantes son los siguientes aspectos para una implementación amplia de nuevos servicios de movilidad en San Luis Potosi? ***

Marca solo un óvalo por fila.

	Nada importante	Poco importante	Importante	Fundamental	Sin opinión
Marcos regulatorios y legislativos favorables					
Posibilidades de financiamiento					
Apertura al cambiar compartamientos de transportarse					
Apertura al compartir recursos en base a tecnologías					
Demanda pública para innovaciones tecnológicas					
Disponibilidad de dispositivos móviles y servicios de internet					
Disponibilidad de estándares y plataformas de TIC					
Disponibilidad de información en tiempo real					
Posibilidad de pagar mediante dispositivo móvil y poder usarlo como un boleto					
Existencia de infraestructura vial adecuada					
Disponibilidad de varios tipos de transportes					
Existencia de un transporte público integrado con densidad y frecuencia adecuada					
Colaboración entre diferentes actores (e.g. compartir datos, alianzas público-privadas)					

21. **Otros aspectos y sus niveles de importancia:**

22. **¿Qué tan favorable o no es la situación actual de los siguientes aspectos de San Luis Potosi para una implementación amplia de nuevos servicios de movilidad? ***

Marca solo un óvalo por fila.

	Muy desfavorable	Desfavorable	Neutral	Favorable	Muy favorable	Sin opinión
Marcos regulatorios y legislativos existentes						
Posibilidades de financiamiento						
Nivel de apertura al cambiar compartamientos de transportarse						
Nivel de apertura al compartir recursos en base a tecnologías						
Nivel de demanda pública para innovaciones tecnológicas						
Disponibilidad actual de dispositivos móviles y servicios de internet						
Disponiblidad actual de estánderes y plataformas de TIC						
Disponibilidad actual de información en tiempo real						
Posibilidades actuales de pagar mediante un dispositivo móvil y usarlo como un boleto						
Infraestructura vial existente						
Disponibilidad actual de tipos de transportes						
Nivel de integración, densidad y frecuencia del transporte público						
Nivel de colaboración entre diferentes actores (e.g. compartir datos, alianzas público-privadas)						

23. **Otros aspectos y sus niveles favorabilidad:**

Horizonte de tiempo

24. **¿Qué acciones a corto, mediano, largo y muy largo plazo se deberían llevar a cabo para fomentar una introducción amplia de nuevos servicios de movilidad en San Luis Potosí que promueva soluciones sustentables? ***

Favor sólo seleccionar el rango de tiempo más apropiado.
Marca solo un óvalo por fila.

	A corto plazo (menos de 1 año)	A mediano plazo (1 - 4 años)	A largo plazo (4 - 10 años)	A muy largo plazo (más de 10 años)	Sin opinión
Analizar potencial e impactos de nuevos servicios de movilidad					
Establecer marco regulatorio y legislativo (incluye responsabilidades, permisos, protección de datos, objetivos de desarrollo sostenible)					
Encontrar posibilidades de financiamiento					
Incentivar cambios en la forma de transportarse					
Incentivar compartir recursos con base en tecnologías					
Incrementar disponibilidad de dispositivos móviles y servicios de internet					
Desarrollar estándares y plataformas de TIC					
Incrementar la disponibilidad de información en tiempo real					
Incrementar el uso de dispositivos móviles como método de pago y como boleto					
Iniciar programas pilotos a pequeña escala					
Adecuar el diseño de la infraestructura vial					
Introducir nuevos modos de transporte (e.g. opción de transporte masivo)					
Incrementar nivel de integración del transporte público y adecuar densidad y frecuencia					
Expansión de integración y combinación de diferentes transportes y servicios					
Incentivar colaboraciones entre actores (e.g. compartir datos, asociaciones público-privadas)					

25. **Otras acciones:**

Preguntas generales

26. **¿En qué rango de tiempo piensa usted que los nuevos servicios de movilidad serán más comunes en San Luis Potosí? ***

Marca solo un óvalo.

- A corto plazo (menos de 1año)
- A mediano plazo (1 - 4 años)
- A largo plazo (4 - 10 años)
- A muy largo plazo (más de 10 años)
- Otros:

27. **¿Por qué razones cree usted que los nuevos servicios de movilidad se volverán o no más comunes en San Luis Potosí? ***

1 - 2 frases

28. **¿De qué manera promueve su empresa / organización nuevos servicios de movilidad?**

Selecciona todas las opciones que correspondan.

- [ ] De ninguna manera
- [ ] Proporciona fondos
- [ ] Proporciona conocimiento técnico
- [ ] Realiza análisis y investigación
- [ ] Maneja una politica de datos abiertos (e.g. permite ver ubicaciones de autobuses en tiempo real)
- [ ] Maneja una politica de APIs abiertos (facilita la combinación de diferentes aplicaciones móviles)
- [ ] Otros:

29. **¿Usted se describiría como un posible usuario de nuevos servicios de movilidad?** *

Marca solo un óvalo.

- Sí
- Tal vez
- No

30. **¿Percibe que los nuevos servicios de movilidad traerán más ventajas o desventajas?** *

Marca solo un óvalo.

- Más ventajas
- Neutral
- Más desventajas

Retroalimentación

31. **Si tiene alguna observación sobre nuevos servicios de movilidad o sobre esta encuesta, por favor menciónelo aquí:**

¡Gracias por su participación!

Con la tecnología de Google Forms

Annex 6. Results - Expert survey about new mobility services.

https://docs.google.com/forms/d/15W0K4FcG0RIdyu1kVwu7aiy1GDA74P8opjyG7l_rNWE/viewanalytics#start=publishanalytics

Annex 7. Individual questionnaire for local transport authority.

Cuestionario sobre transporte y movilidad en San Luis Potosí

La movilidad urbana, como muchos otros aspectos de la vida cotidiana en una ciudad, han tenido un cambio radical debido a diferentes tendencias en nuestra sociedad, tal como es el uso creciente de tecnologías de la información y la comunicación. El fácil acceso y rapidez mediante el uso de dispositivos móviles plantea transformaciones en la manera como nos desplazamos.

La Facultad de Ingeniería y la Facultad del Habitat de la UASLP realizan un estudio sobre la movilidad de San Luis Potosí. Particularmente se elabora una tesis de Maestría en Ciencias Ambientales que analiza los potenciales e impactos de nuevos servicios de movilidad (ej. Uber, Moovit, etc.) en San Luis Potosí. Además, se busca identificar qué características presentes en la capital potosina son favorables o no para el uso de estas tecnologías.

El siguiente cuestionario está diseñado para recopilar datos de la Secretaría de Comunicaciones y Transporte (SCT) relacionados con la movilidad urbana en San Luis Potosí. Tomará aproximadamente 20 minutos completarlo. La información obtenida será utilizada exclusivamente con fines académicos. Si tiene alguna duda, puede ponerse en contacto con dimitrios.thanos@outlook.com.

¡Muchas gracias por su tiempo y apoyo!

Comience ahora el cuestionario haciendo clic en el botón "Siguiente".

*Obligatorio

FACULTAD DE INGENIERÍA FACULTAD DEL HABITAT UASLP Universidad Autónoma de San Luis Potosí

Instrucciones

Para responder las siguientes preguntas hay dos pequñas instrucciones:

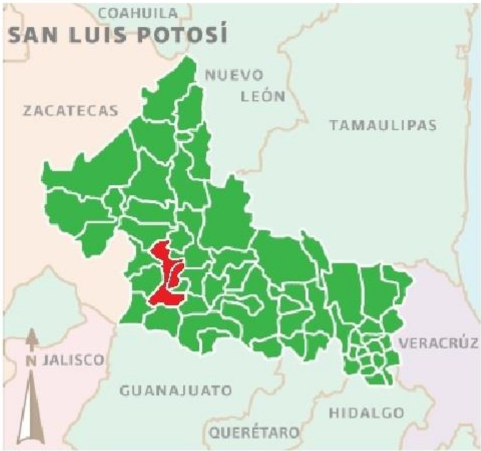
1.
Todas las preguntas de este cuestionario están dirigidas a la Zona Metropolitana de San Luis Potosi (ZMSLP).
La ZMSLP está delimitada geograficamente como el área combinado de los municipios de San Luis Potosi y Soledad de Graciano Sánchez, tal como se presenta en el mapa más abajo.

Si el dato que usted tiene disponible NO corresponde al área de la ZMSLP, favor de INDICAR LA DELIMITACIÓN GEOGRÁFICA al que se refiere su dato.

2.
Todas las preguntas de este cuestionario están dirigidas a obtener los datos más actualizados disponibles, es decir preferiblemente del año 2017.

Si el dato más actualizado que usted tiene disponible NO es del año 2017, favor de INDICAR EL AÑO al que se refiere su dato.

Zona Metropolitana de San Luis Potosí (en rojo)



He leido y entendido las instrucciones. *
Marca solo un óvalo.

- ( ) Sí
- ( ) No *Pasa a la pregunta 1.*

Transporte individual motorizado

1. ¿Cuántos automóviles existen actualmente en la Zona Metropolitana de San Luis Potosí (ZMSLP)?
Si su dato disponible no coincide con las instrucciones, indique la delimitación geográfica y/o el año al que se refiere el dato.

1.1 Confiabilidad de este dato:
Marca solo un óvalo.

- ( ) Muy confiable (dato oficial)
- ( ) Confiable
- ( ) Más o menos confiable
- ( ) No confiable

2. ¿Cuántos habitantes de la ZMSLP tienen actualmente una licencia de conducir?
Si su dato disponible no coincide con las instrucciones, indique la delimitación geográfica y/o el año al que se refiere el dato.

2.1 Confiabilidad de este dato:
Marca solo un óvalo.

- ( ) Muy confiable (dato oficial)
- ( ) Confiable
- ( ) Más o menos confiable
- ( ) No confiable

3. ¿Cómo se distribuyen los propietarios de automóviles conforme a los rangos de edad?
El total de los porcentajes debe sumar 100%.
Marca solo un óvalo por fila.

	~0%	~5%	~10%	~15%	~20%	~30%	~40%	~50%
18-30 años	( )	( )	( )	( )	( )	( )	( )	( )
30-40 años	( )	( )	( )	( )	( )	( )	( )	( )
40-50 años	( )	( )	( )	( )	( )	( )	( )	( )
50-60 años	( )	( )	( )	( )	( )	( )	( )	( )
Más de 60 años	( )	( )	( )	( )	( )	( )	( )	( )

3.1 Confiabilidad de este dato:
Marca solo un óvalo.

- ( ) Muy confiable (dato oficial)
- ( ) Confiable
- ( ) Más o menos confiable
- ( ) No confiable

Transporte público y servicio de taxi

1. ¿Cuántas unidades de autobuses de transporte público operan actualmente en la ZMSLP?
Si su dato disponible no coincide con las instrucciones, indique la delimitación geográfica y/o el año al que se refiere el dato.

1.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

2. ¿Cuántos concesionarios de autobuses de transporte público hay actualmente en la ZMSLP?
Si su dato disponible no coincide con las instrucciones, indique la delimitación geográfica y/o el año al que se refiere el dato.

2.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

3. ¿Cuántas unidades de taxis operan actualmente en la ZMSLP?
Si su dato disponible no coincide con las instrucciones, indique la delimitación geográfica y/o el año al que se refiere el dato.

3.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

4. ¿Cuántos concesionarios de taxis hay actualmente en la ZMSLP?
Si su dato disponible no coincide con las instrucciones, indique la delimitación geográfica y/o el año al que se refiere el dato.

4.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

5. ¿Cuál es el porcentaje estimado de ingresos que ha dejado de recibir un taxista desde la introducción de Uber en la ZMSLP?
Marca solo un óvalo.

- El ingreso sigue siendo igual
- 0-10%
- 10-20%
- 20-30%
- 30-40%
- 40-50%
- Más de 50%
- El ingreso no disminuyó, se incrementó

5.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable
- Confiable
- Más o menos confiable
- No confiable

Uber

1. ¿Cuántos conductores de Uber hay actualmente (en total) en la ZMSLP?

1.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable
- Confiable
- Más o menos confiable
- No confiable

2. ¿Cuántas unidades de Uber operan actualmente en promedio durante un día en la ZMSLP?

2.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable
- Confiable
- Más o menos confiable
- No confiable

3. ¿Cuántos usuarios de Uber existen actualmente en la ZMSLP?

3.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable
- Confiable
- Más o menos confiable
- No confiable

4. ¿Cuál es el porcentaje de Uber en el "reparto modal" de la ZMSLP?
Reparto modal: porcentaje de viajes realizados en un modo de transporte (en este caso Uber) con relación a los otros.
Marca solo un óvalo.

- 0 - 0,5%
- 0,5 - 1%
- 1 - 2%
- 2 - 3%
- 3 - 4%
- 4 - 5%
- 5 - 10%
- Más de 10%

4.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable
- Confiable
- Más o menos confiable
- No confiable

Nuevos servicios de movilidad con base en dispositivos móviles

1. Señale cuáles nuevos servicios de movilidad existen en San Luis Potosí y si permiten o no realizar pagos desde un dispositivo móvil. Servicios para...

Entre paréntesis se mencionan explicaciones del tipo de servicio y ejemplos de diferentes aplicaciones para dispositivos móviles.
Marca solo un óvalo por fila.

	No existe	Pronto estará disponible	Sí existe pero sin opción de pago	Sí existe con opción de pago	Desconozco
...planear viajes, integrando diferentes modos de transporte (ej. Moovit)					
...taxis oficiales (ej. StopTaxi, MyTaxi)					
...transporte a pedido "tipo" taxi (ej. Uber)					
...transporte colectivo a pedido (ej. UberPOOL, Via; haciendo coincidir a varios pasajeros con un vehiculo disponible)					
...compartir bicicletas - "Bikesharing" (ej. Ecobici)					
...compartir automóviles - "Carsharing"					
...compartir automóviles privados (propietarios de automóviles privados ponen a disposición sus vehiculos para alquiler por periodos cortos de tiempo)					
...viajes compartidos intra- e interurbanos (ej. Split, BlaBlaCar)					
...viajes interurbanos en autobuses y transporte aéreo (ej. aplicaciones de Primera Plus, Volaris)					
...indicar disponibilidad de estacionamientos para automóviles					
...compartir estacionamientos privados (propietarios de estacionamientos de automóviles ponen a disposición sus estacionamientos para alquiler por periodos cortos de tiempo)					
...entrega de alimentos y de compras en general (ej. UberEATS)					

2. ¿Qué otros competidores o servicios parecidos a Uber (e.g. Cabify) existen actualmente en la ZMSLP?

3. ¿Se planea a futuro que otros competidores o servicios parecidos a Uber se instalen en la ZMSLP? ¿Cuáles y en qué periodo de tiempo?

4. ¿Qué instituciones están a cargo de la legislación y regulaciones para la movilidad y el transporte de la ZMSLP?

5. ¿Qué tipo de licencias / permisos / seguros son necesarios para implementar nuevos servicos de movilidad en la ZMSLP?

Tome como ejemplo el caso de Uber.

6. ¿Quiénes son los actores (instituciones, empresas privadas, etc.) relevantes para otorgar estas licencias / permisos / seguros?

7. ¿Se planea en la SCT Estatal de introducir o fomentar nuevos servicios de movilidad? ¿Cuáles?, ¿cómo? y ¿en qué periodo de tiempo?

Internet móvil y Wifi público

1. ¿Qué tipo de internet móvil existe actualmente en la ZMSLP?

Selecciona todas las opciones que correspondan.

- [ ] 3G
- [ ] LTE
- [ ] 4G
- [ ] 5G
- [ ] Otros: ______

2. ¿Se planea implementar internet móvil tipo 5G en la ZMSLP? ¿Cuándo?

3. ¿Qué porcentaje de la superficie de la ZMSLP cubre la red del internet móvil actualmente?

Recuerde: La ZMSLP consiste de los municipios San Luis Potosí y Soledad de Graciano Sánchez.
Marca solo un óvalo.

- Menos de 20%
- 20 - 30%
- 30-40%
- 40-50%
- 50-60%
- 60-70%
- 70-80%
- 80-90%
- 90-100%

3.1 Confiabilidad de este dato:

Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

4. ¿Cuántos lugares con Wifi público ofrece la ZMSLP actualmente (e.g. plazas públicas, etc.)?

4.1 Confiabilidad de este dato:

Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

5. ¿Cuáles son los planes a futuro para ampliar la oferta de Wifi público en la ZMSLP?

Inversiones, subvenciones e incentivos en transporte y movilidad

1. ¿Cómo se distribuye el monto de inversiones destinados a los distintos tipos de transporte en esta última administración estatal (2015)?

El total de los porcentajes tiene que sumar 100%.
Marca solo un óvalo por fila.

	~0%	~10%	~20%	~30%	~40%	~50%	~60%	~70%	~80%	~90%	~100%
Transporte público											
Transporte individual motorizado											
Transporte no motorizado											

1.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

2. ¿Se priorizó algún tipo de transporte? ¿Cuál y por qué?

3. ¿Cuál ha sido el monto de inversión en infraestructura destinado al transporte individual motorizado en esta última administración estatal?

3.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

4. ¿Cuál ha sido el monto de inversión en infraestructura destinado al transporte público en esta última administración estatal?

4.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

5. ¿Cuál ha sido el monto de inversión en infraestructura destinado al transporte no motorizado en esta última administración estatal?

5.1 Confiabilidad de este dato:
Marca solo un óvalo.

- Muy confiable (dato oficial)
- Confiable
- Más o menos confiable
- No confiable

6. ¿Qué tipo de subsidios o incentivos contemplados en políticas públicas fomentan el uso del automóvil individual en San Luis Potosí?

7. ¿Qué tipo de subsidios o incentivos contemplados en políticas públicas fomentan el uso del transporte público en San Luis Potosí?

8. ¿Qué tipo de subsidios o incentivos contemplados en políticas públicas fomentan el uso de transportes no motorizados en San Luis Potosí?

9. ¿Cuáles desincentivos contemplados en políticas públicas existen actualmente para disminuir el uso y la tenencia de automóviles?

10. ¿Su institución incluye objetivos de desarrollo sostenible planteados por la ONU? ¿Cuáles objetivos? ¿Qué hace su institución para lograrlos?

Combustibles y emisiones

1. ¿Qué tipo de combustible usan los autobuses de transporte público?

2. ¿Cuánto CO2 (g/km), NOx (mg/km) y PM10 (mg/km) emite en promedio un autobús de transporte público?

2.1 Confiabilidad de estos datos:
Marca solo un óvalo.

- Muy confiable (datos oficiales)
- Confiable
- Más o menos confiable
- No confiable

3. ¿Qué tipo de combustible usan las unidades de taxi?
Tanto de la vieja generación (Nissan Tsuru), como de la nueva generación (Nissar Versa).

4. ¿Cuánto CO2 (g/km), NOx (mg/km) y PM10 (mg/km) emite en promedio una unidad de taxi?
Tanto de la vieja generación (Nissan Tsuru), como de la nueva generación (Nissar Versa).

4.1 Confiabilidad de estos datos:
Marca solo un óvalo.

- Muy confiable (datos oficiales)
- Confiable
- Más o menos confiable
- No confiable

5. ¿Qué tipo de combustible usarán las unidades del "Metrobús"?

6. ¿Cuánto CO2 (g/km), NOx (mg/km) y PM10 (mg/km) emitirá en promedio una unidad del "Metrobús"?

6.1 Confiabilidad de estos datos:
Marca solo un óvalo.

- Muy confiable (datos oficiales)
- Confiable
- Más o menos confiable
- No confiable

7. ¿Cuál modelo / marca de vehículo se utilizará para el "Metrobús"?

8. ¿Se planea utilizar combustibles y unidades de transporte público más amigables para el medio ambiente? ¿Cuáles y en qué periodo de tiempo?

Retroalimentación

Si tiene alguna observación sobre este cuestionario, por favor menciónelo aquí:

¡Gracias por su participación!

Con la tecnología de Google Forms

Annex 8. Results - Individual questionnaire for local transport authority.

https://docs.google.com/forms/d/1DGm0dvYM6_iZBDCKLzpDY5wD4nCOikQsZCk6pqHgddM/viewanalytics#start=publishanalytics

Annex 9. Verification of scoring data.

San Luis Potosí, el 15 de diciembre de 2017

Primera fase del taller para la evaluación del MaaS Readiness Index

Organizador del taller:
Dimitrios Thanos

El taller es parte del proyecto de tesis del Lic. Dimitrios Thanos, aspirante al título de Maestro en Ciencias Ambientales:
Towards Sustainable Mobility-as-a-Service: A Roadmap for San Luis Potosí, MX, Using the MaaS Readiness Index

- La metodología del proyecto de tesis requiere que todos los contenidos que servirán como base para la evaluación del MaaS Readiness Index, tienen que ser controlados por un auditor externo que confirma si las informaciones son verdaderas y acertadas.

Nombre del Auditor externo:
Maestro Adrián Moreno Mata

Descripción de la posición (puesto) de trabajo del auditor externo:

Profesor-Investigador T.C. Facultad del Hábitat, UASLP

Experiencia en el campo de movilidad urbana y movilidad inteligente:

- He publicado un libro sobre Smart Cities en Mexico y varios capítulos o artículos especializados en Planeación Urbana, Movilidad Urbana Sustentable y Smart Cities.
- He dirigido 4 tesis de posgrado sobre Movilidad Urbana
- Tengo amplia experiencia como Consultor en Desarrollo Urbano.

Por la presente, yo, Adrián Moreno Mata, confirmo que todos los contenidos que servirán como base para evaluar el MaaS Readiness Index son verdaderos y acertados. Por lo tanto, se pueden utilizar para el taller de evaluación del índice, tal como se indica en la metodología.

....	San Luis Potosí, SLP / 15 / DIC. / 2017.
Adrián Moreno Mata	Lugar y fecha

Annex 10. MRI registration and scoring papers.

Benjamín Alva Fuentes

San Luis Potosí, el 18 de diciembre de 2017

Taller sobre Movilidad-como-Servicio (MaaS) en San Luis Potosí:
Evaluación del MaaS Readiness Index

Organizador:
Dimitrios Thanos
Lugar:
Facultad del Hábitat, UASLP
Hora:
11pm-1am

El taller es parte del proyecto de tesis del Lic. Dimitrios Thanos, aspirante al título de Maestro en Ciencias Ambientales:

Towards Sustainable Mobility-as-a-Service:
A Roadmap for San Luis Potosí, MX, Using the MaaS Readiness Index
Hacia la Movilidad-como-Servicio:
Una Hoja de Ruta para San Luis Potosí, MX, Usando el índice de MaaS Readiness

Nombre del Evaluador/ de la Evaluadora:

Benjamin Alva Fuentes

Descripción de la posición (puesto) de trabajo:

Coordinador Investigación Facultad del Hábitat

Experiencia en el campo de movilidad urbana y movilidad inteligente:

Elaboración de proyectos para la ciudad, tesis de investigación

Por la presente, yo, Benjamin Alva, confirmo que he participado como evaluador del MaaS Readiness Index en el taller de Dimitrios Thanos sobre Movilidad-como-Servicio en San Luis Potosí.

Firma

S.L.P. 18/DIC/17
Lugar y fecha

1

Sistema de puntaje del índice.

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4 = Totalmente favorable para MaaS

Dimensión de primer nivel	Dimensión de segundo nivel	Dimensión de tercer nivel	Factores para evaluar	Puntaje
Disponibilidad de servicios de transporte, movilidad y TIC	Transporte activo	Caminar	Reparto modal de "caminar"	2 ✓
			Infraestructura peatonal	2 ✓
		Bicicleta	Reparto modal de la "bicicleta"	2 ✓
			Infraestructura ciclista	1 ✓
		Bicicleta compartida	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
	Transporte público	Servicio de transporte público	Reparto modal de "transporte público"	~~2~~ 3
			Infraestructura del transporte público	2 ✓
		Planeador del viaje	Cobertura y densidad del servicio	~~3~~ 2
			Funciones del servicio	~~3~~ 2
			API's	1
		Transporte público colectivo a pedido	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
	Transporte vehícular particular	Vehículo personal	Reparto modal de "vehículo personal"	3 ✓
			Infraestructura del transporte vehícular	~~4~~ 2
		Taxi	Cobertura y densidad del servicio	~~3~~ 2
			Cobertura y densidad del servicio móvil	~~3~~ 2
			Funciones del servicio móvil	2 ✓
			API's	1
		Transporte individual a pedido	Cobertura y densidad del servicio	3 ✓
			Funciones del servicio	3 ✓
			API's	~~4~~ 3

2

Disponibilidad de servicios de transporte, movilidad y TIC	Acceso flexible a vehículos	Alquiler de vehículos	Cobertura y densidad del servicio	1 ✓
			Cobertura y densidad del servicio móvil	~~1~~ 2
			Funciones del servicio móvil	~~1~~ 3
			API's	~~1~~ 3
		Vehículos compartidos	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Estaciona-mientos	Cobertura y densidad del servicio	1 ✓
			Funciones del servicio	2 ✓
			API's	1
	Acceso flexible a viajes	Transporte privado colectivo a pedido	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Viajes compartidos intraurbanos	Cobertura y densidad del servicio	1 ✓
			Funciones del servicio	~~1~~ 3
			API's	1
		Viajes compartidos interurbanos	Cobertura y densidad del servicio	~~1~~ 2
			Funciones del servicio	~~1~~ 3
			API's	~~1~~ 2
		Otros transporte interurbanos	Cobertura y densidad del servicio	~~3~~ 2
			Cobertura y densidad del servicio móvil	2 ✓
			Funciones del servicio móvil	~~1~~ 2
			API's	2 ✓
	Servicios adicionales	Servicio de entrega de alimentos	Cobertura y densidad del servicio	2 1
			Funciones del servicio	2 1
			API's	1
		Servicio de entrega de compras	Cobertura y densidad del servicio	2 1
			Funciones del servicio	2 1
			API's	1
		Servicio de logística	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1

3

Disponibilidad de servicios de transporte, movilidad y TIC	Servicios de TIC	Dispositivos móviles	Disponibilidad de dispositivos móviles	1 3
		Internet	Cobertura y densidad de servicio Wifi	2 ✓
			Cobertura y densidad de internet móvil	2 *
		Pago sin contacto	Cobertura y densidad del servicio	1 ✓
			Funciones del servicio	1 X 2
Demanda de usuarios	Conside-raciones demográficas		Demografía general de San Luis Potosí	3 2
			Características demográficas de potenciales prioneros	2 3
	Conside-raciones actituti-dinales		Actitud hacia nuevos servicios de movilidad	1 2
			Actitud hacia la propiedad de un vehículo particular	1 2
Entorno regulativo, legislativo y político			Nivel de facilitación política	2 ✓
			Inversiones públicas en infraestructuras	1 ✓
			Nivel de colaboración entre actores	2 ✓
			Seguridad de datos, privacidad y responsabilidad	1 ✓

4

Ricardo Pérez Castillo

San Luis Potosí, el 18 de diciembre de 2017

Taller sobre Movilidad-como-Servicio (MaaS) en San Luis Potosí:
Evaluación del MaaS Readiness Index

Organizador:
Dimitrios Thanos
Lugar:
Facultad del Hábitat, UASLP
Hora:
11pm-2am

El taller es parte del proyecto de tesis del Lic. Dimitrios Thanos, aspirante al título de Maestro en Ciencias Ambientales:

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Hacia la Movilidad-como-Servicio:
Una Hoja de Ruta para San Luis Potosí, MX, Usando el índice de MaaS Readiness

Nombre del Evaluador/ de la Evaluadora:

RICARDO PEREZ CASTILLO

Descripción de la posición (puesto) de trabajo:

PRESIDENTE DE LA UNION DE USUARIOS DE LA ZONA INDUSTRIAL DE SAN LUIS POTOSI

Experiencia en el campo de movilidad urbana y movilidad inteligente:

PROMOTOR DE METODOLOGIA DE MEJORA CONTINUA EN EL AREA DE MOVILIDAD EN LA ZONA INDUSTRIAL DE S.L.P.

Por la presente, yo, RICARDO PEREZ CASTILLO, confirmo que he participado como evaluador del MaaS Readiness Index en el taller de Dimitrios Thanos sobre Movilidad-como-Servicio en San Luis Potosí.

[signature]
Firma

SAN LUIS POTOSI, S.L.P.
18 DIC 2017
Lugar y fecha

1

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Dimensión de primer nivel	Dimensión de segundo nivel	Dimensión de tercer nivel	Factores para evaluar	Puntaje
Disponibilidad de servicios de transporte, movilidad y TIC	Transporte activo	Caminar	Reparto modal de "caminar"	2
			Infraestructura peatonal	2
		Bicicleta	Reparto modal de la "bicicleta"	2
			Infraestructura ciclista	1
		Bicicleta compartida	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
	Transporte público	Servicio de transporte público	Reparto modal de "transporte público"	3
			Infraestructura del transporte público	2
		Planeador del viaje	Cobertura y densidad del servicio	2
			Funciones del servicio	2
			API's	1
		Transporte público colectivo a pedido	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
	Transporte vehícular particular	Vehículo personal	Reparto modal de "vehículo personal"	3
			Infraestructura del transporte vehícular	2
		Taxi	Cobertura y densidad del servicio	2
			Cobertura y densidad del servicio móvil	2
			Funciones del servicio móvil	2
			API's	1
		Transporte individual a pedido	Cobertura y densidad del servicio	4
			Funciones del servicio	4
			API's	4

2

Disponibilidad de servicios de transporte, movilidad y TIC	Acceso flexible a vehículos	Alquiler de vehículos	Cobertura y densidad del servicio	2
			Cobertura y densidad del servicio móvil	2
			Funciones del servicio móvil	3
			API's	3
		Vehículos compartidos	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Estaciona-mientos	Cobertura y densidad del servicio	1
			Funciones del servicio	2
			API's	1
	Acceso flexible a viajes	Transporte privado colectivo a pedido	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Viajes compartidos intraurbanos	Cobertura y densidad del servicio	1
			Funciones del servicio	3
			API's	1
		Viajes compartidos interurbanos	Cobertura y densidad del servicio	2
			Funciones del servicio	3
			API's	3
		Otros transporte interurbanos	Cobertura y densidad del servicio	2
			Cobertura y densidad del servicio móvil	2
			Funciones del servicio móvil	2
			API's	1
	Servicios adicionales	Servicio de entrega de alimentos	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Servicio de entrega de compras	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Servicio de logística	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1

3

Disponibilidad de servicios de transporte, movilidad y TIC	Servicios de TIC	Dispositivos móviles	Disponibilidad de dispositivos móviles	~~4~~3
		Internet	Cobertura y densidad de servicio Wifi	2
			Cobertura y densidad de internet móvil	2
		Pago sin contacto	Cobertura y densidad del servicio	2
			Funciones del servicio	2
Demanda de usuarios	Conside-raciones demográficas		Demografía general de San Luis Potosí	4
			Características demográficas de potenciales prioneros	
	Conside-raciones actituti-dinales		Actitud hacia nuevos servicios de movilidad	3
			Actitud hacia la propiedad de un vehículo particular	3
Entorno regulativo, legislativo y político			Nivel de facilitación política	2
			Inversiones públicas en infraestructuras	1
			Nivel de colaboración entre actores	1
			Seguridad de datos, privacidad y responsabilidad	~~4~~1

4

Martha Patricia Rivera Torres

San Luis Potosí, el 18 de diciembre de 2017

Taller sobre Movilidad-como-Servicio (MaaS) en San Luis Potosí:
Evaluación del MaaS Readiness Index

Organizador:
Dimitrios Thanos
Lugar:
Facultad del Hábitat, UASLP
Hora:
11pm-2am

El taller es parte del proyecto de tesis del Lic. Dimitrios Thanos, aspirante al título de Maestro en Ciencias Ambientales:

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Una Hoja de Ruta para San Luis Potosí, MX, Usando el índice de MaaS Readiness

Nombre del Evaluador/ de la Evaluadora:

Martha Patricia Rivera Torres

Descripción de la posición (puesto) de trabajo:

Director General de Conectividad

Experiencia en el campo de movilidad urbana y movilidad inteligente:

1 1/2 años en la Secretaría de Comunicaciones y Transportes

Por la presente, yo, Martha Patricia Rivera Torres, confirmo que he participado como evaluador del MaaS Readiness Index en el taller de Dimitrios Thanos sobre Movilidad-como-Servicio en San Luis Potosí.

Firma

San Luis Potosí, SLP a 18 de Diciembre de 2017
Lugar y fecha

1

Sistema de puntaje del índice.

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Dimensión de primer nivel	Dimensión de segundo nivel	Dimensión de tercer nivel	Factores para evaluar	Puntaje
Disponibilidad de servicios de transporte, movilidad y TIC	Transporte activo	Caminar	Reparto modal de "caminar"	2
			Infraestructura peatonal	2
		Bicicleta	Reparto modal de la "bicicleta"	2
			Infraestructura ciclista	1
		Bicicleta compartida	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
	Transporte público	Servicio de transporte público	Reparto modal de "transporte público"	3
			Infraestructura del transporte público	2
		Planeador del viaje	Cobertura y densidad del servicio	2
			Funciones del servicio	2
			API's	1
		Transporte público colectivo a pedido	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
	Transporte vehícular particular	Vehículo personal	Reparto modal de "vehículo personal"	3
			Infraestructura del transporte vehícular	2
		Taxi	Cobertura y densidad del servicio	2
			Cobertura y densidad del servicio móvil	2
			Funciones del servicio móvil	2
			API's	1
		Transporte individual a pedido	Cobertura y densidad del servicio	3
			Funciones del servicio	3
			API's	3

2

MAAS = Mobility as a Service

Disponibilidad de servicios de transporte, movilidad y TIC	Acceso flexible a vehículos	Alquiler de vehículos	Cobertura y densidad del servicio	2
			Cobertura y densidad del servicio móvil	2
			Funciones del servicio móvil	3
			API's	3
		Vehículos compartidos	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Estaciona-mientos	Cobertura y densidad del servicio	1
			Funciones del servicio	2
			API's	1
	Acceso flexible a viajes	Transporte privado colectivo a pedido	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Viajes compartidos intraurbanos	Cobertura y densidad del servicio	1
			Funciones del servicio	3
			API's	1
		Viajes compartidos interurbanos	Cobertura y densidad del servicio	2
			Funciones del servicio	3
			API's	2
		Otros transporte interurbanos	Cobertura y densidad del servicio	2
			Cobertura y densidad del servicio móvil	2
			Funciones del servicio móvil	2
			API's	2
	Servicios adicionales	Servicio de entrega de alimentos	Cobertura y densidad del servicio	2 1
			Funciones del servicio	2 1
			API's	1 1
		Servicio de entrega de compras	Cobertura y densidad del servicio	2 1
			Funciones del servicio	2 1
			API's	1 1
		Servicio de logística	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1

3

Disponibilidad de servicios de transporte, movilidad y TIC	Servicios de TIC	Dispositivos móviles	Disponibilidad de dispositivos móviles	3	[illegible]
		Internet	Cobertura y densidad de servicio Wifi	3	
			Cobertura y densidad de internet móvil	2	3
		Pago sin contacto	Cobertura y densidad del servicio	2	
			Funciones del servicio	2	
Demanda de usuarios	Conside-raciones demográficas		Demografía general de San Luis Potosí	2	3
			Características demográficas de potenciales prioneros	3	✓
	Conside-raciones actituti-dinales		Actitud hacia nuevos servicios de movilidad	3	2
			Actitud hacia la propiedad de un vehículo particular	2	✓
Entorno regulativo, legislativo y político			Nivel de facilitación política	3	2
			Inversiones públicas en infraestructuras	3	1
			Nivel de colaboración entre actores	3	2
			Seguridad de datos, privacidad y responsabilidad	[illegible]	4

4

Nancy Hernández del Ángel

San Luis Potosí, el 18 de diciembre de 2017

Taller sobre Movilidad-como-Servicio (MaaS) en San Luis Potosí:
Evaluación del MaaS Readiness Index

Organizador:
Dimitrios Thanos
Lugar:
Facultad del Hábitat, UASLP
Hora:
11pm-2am

El taller es parte del proyecto de tesis del Lic. Dimitrios Thanos, aspirante al título de Maestro en Ciencias Ambientales:

Towards Sustainable Mobility-as-a-Service:
A Roadmap for San Luis Potosí, MX, Using the MaaS Readiness Index
Hacia la Movilidad-como-Servicio:
Una Hoja de Ruta para San Luis Potosí, MX, Usando el índice de MaaS Readiness

Nombre del Evaluador/ de la Evaluadora:

Nancy Arely Hernández del Ángel

Descripción de la posición (puesto) de trabajo:

Directora de Conectividad y Telecomunicaciones

Experiencia en el campo de movilidad urbana y movilidad inteligente:

Experiencia por más de 8 años en Secretaría de Comunicaciones y Transportes, fui Directora General de Comunicaciones y Transportes y actualmente Directora de Conectividad y Telecomunicaciones.

Por la presente, yo, Nancy Arely Hernández del Ángel, confirmo que he participado como evaluador del MaaS Readiness Index en el taller de Dimitrios Thanos sobre Movilidad-como-Servicio en San Luis Potosí.

Firma

San Luis Potosí, SLP 18 Dic 2017
Lugar y fecha

1

Sistema de puntaje del índice.

1 = No existe este factor o existe una barrera crítica para ser de utilidad en MaaS
2 = Alguna utilidad para MaaS, pero por debajo de lo que sería deseable
3 = Favorable para MaaS, pero existen algunas brechas
4 = Totalmente favorable para MaaS

Dimensión de primer nivel	Dimensión de segundo nivel	Dimensión de tercer nivel	Factores para evaluar	Puntaje
Disponibilidad de servicios de transporte, movilidad y TIC	Transporte activo	Caminar	Reparto modal de "caminar"	2
			Infraestructura peatonal	1
		Bicicleta	Reparto modal de la "bicicleta"	2
			Infraestructura ciclista	1
		Bicicleta compartida	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
	Transporte público	Servicio de transporte público	Reparto modal de "transporte público"	3
			Infraestructura del transporte público	2
		Planeador del viaje	Cobertura y densidad del servicio	3
			Funciones del servicio	2
			API's	1
		Transporte público colectivo a pedido	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
	Transporte vehícular particular	Vehículo personal	Reparto modal de "vehículo personal"	3
			Infraestructura del transporte vehícular	3
		Taxi	Cobertura y densidad del servicio	2
			Cobertura y densidad del servicio móvil	2
			Funciones del servicio móvil	3
			API's	1
		Transporte individual a pedido	Cobertura y densidad del servicio	4
			Funciones del servicio	4
			API's	3

2

Disponibilidad de servicios de transporte, movilidad y TIC	Acceso flexible a vehículos	Alquiler de vehículos	Cobertura y densidad del servicio	1
			Cobertura y densidad del servicio móvil	1
			Funciones del servicio móvil	3
			API's	3
		Vehículos compartidos	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Estaciona-mientos	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
	Acceso flexible a viajes	Transporte privado colectivo a pedido	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Viajes compartidos intraurbanos	Cobertura y densidad del servicio	1
			Funciones del servicio	3
			API's	1
		Viajes compartidos interurbanos	Cobertura y densidad del servicio	1
			Funciones del servicio	3
			API's	3
		Otros transporte interurbanos	Cobertura y densidad del servicio	2
			Cobertura y densidad del servicio móvil	1
			Funciones del servicio móvil	2
			API's	1
	Servicios adicionales	Servicio de entrega de alimentos	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Servicio de entrega de compras	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1
		Servicio de logística	Cobertura y densidad del servicio	1
			Funciones del servicio	1
			API's	1

3

Disponibilidad de servicios de transporte, movilidad y TIC	Servicios de TIC	Dispositivos móviles	Disponibilidad de dispositivos móviles	3
		Internet	Cobertura y densidad de servicio Wifi	2
			Cobertura y densidad de internet móvil	2
		Pago sin contacto	Cobertura y densidad del servicio	2
			Funciones del servicio	1
Demanda de usuarios	Conside-raciones demográficas		Demografía general de San Luis Potosí	2
			Características demográficas de potenciales prioneros	3
	Conside-raciones actituti-dinales		Actitud hacia nuevos servicios de movilidad	2
			Actitud hacia la propiedad de un vehículo particular	2
Entorno regulativo, legislativo y político			Nivel de facilitación política	2
			Inversiones públicas en infraestructuras	1
			Nivel de colaboración entre actores	2
			Seguridad de datos, privacidad y responsabilidad	1

4

Annex 11. Explanatory MaaS video (English, subtitled in Spanish).

https://www.youtube.com/watch?v=LDyd1PAYoS0&t=

Annex 12. Slide show for scoring workshop.

https://prezi.com/view/t17v372viIn5bWrl5Lwf/