SHARED MOBILITY

International Scan on Mobility Strategies

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ACRONYMS

API	Application programming interface
B2B	Business-to-business
B2P	Business-to-people
EC	European Commission
EU	European Union
GDP	Gross domestic product
GMA	Greater Montreal Area
GPS	Global positioning system
ICT	Information and communications technology
ITF	International transport forum
MaaS	Mobility-as-a-Service
OECD	Organization for Economic Co-operation and Development
P2P	Peer-to-peer
PKM	Passenger kilometer
PT	Public transport
PTA	Public transport authority
TNC	Transportation Network Company
UITP	International Association of Public Transport
VKM	Vehicle kilometer
VKT	Vehicle kilometers traveled

COUNTRIES

AUS	Australia
CAN	Canada
CNA	China
DNK	Denmark
EST	Estonia
GER	Germany
IND	India
JPN	Japan
KOR	Korea
NDL	Netherlands
SGP	Singapore
SWE	Sweden

MONETARY UNITS

AUS	Australian dollar
CAD	Canadian dollar
DKK	Danish krone
EUR	Euro
PPP	Purchase power parity
SGD	Singapore dollar
USD	American dollar

TABLE ACRONYMS

k	Thousand
n	Number
NA	Non available
M	Million

Introduction

The recent enthusiasm for multimodality is part of a growing awareness of the environmental, social, and economic impacts of individual car ownership. The diversification and integration of various modes of transport are a way to mitigate congestion problems and generate gains in terms of spatial and temporal accessibility. In parallel, a smart mobility industry has emerged propelled by technological advancements in software engineering, collection, and storage of big data as well as smartphone adoption. Nowadays, many cities have shared mobility services (car, bike, scooter), hailing services, carpooling platforms, real-time public transport services, and smart parking pricing that contribute to optimize travel demand in space and time. With the development of teleworking and coworking spaces, the very definition of mobility is even changing.

As the urban transport ecosystem becomes more complex, public authorities are wondering how to integrate these different services wisely. A new term is gaining traction, mobility-as-a-service (MaaS), propelled by academics but mostly companies offering smart solutions. In the opinion of several specialists, technological issues are however not the most important challenges related to MaaS implementation. It must be recognized that the market is evolving faster now than our ability to understand it. Many questions remain concerning the benefits and the winning conditions (with regard to land-use planning, regulations and economic incentives) for implementing these various shared modes while a new layer of questions is added on top as we now seek to develop risk, profit and data sharing models to integrate them.

The objective of this project is to provide an international scan on shared mobility strategies. Results will help support Transportation 2030, the long-term strategic plan of Transport Canada, which emerged from a public consultation conducted in 2016. With respect to green and innovative transportation, participants emphasized the importance of focusing on shared ways of moving goods and people.

The first section of this report proposes a typology of shared mobility services and a look at its recent inclusion into the concept of mobility-as-a-service (MaaS) as illustrated in Figure 1. This section also offers a brief literature review on multimodality and shared mobility services impacts. The second section presents a series of case studies on the integration of shared mobility in cities and countries considered to be at the forefront internationally.

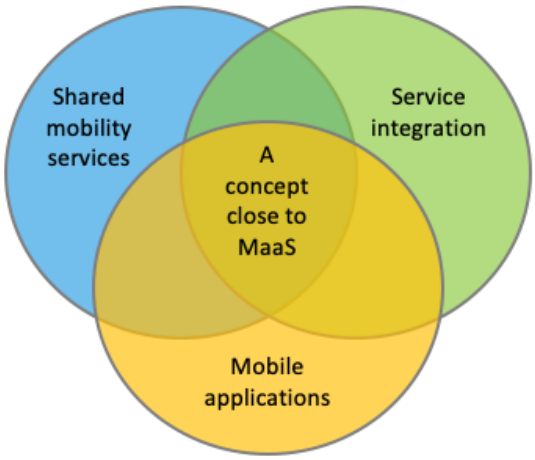


Figure 1: Theme discussed in this report
Source: adapted from NITPA (2019)

1 Key concepts

1.1 Role and goals of shared mobility and other disruptive technologies

In Europe, the annual costs of negative externalities caused by transport (infrastructure spending not included) have been estimated at 1,000 billion euros (7 % of gross domestic product (GDP)) of which 75% is attributable to the automobile. More than half of these costs are attributable to accidents and congestion. In 2015, the European Commission (EC) estimated that road accident would have caused 26,134 deaths and 1,1 million injuries. In this context, the EC has proclaimed 2018 the year of multimodality (EC, 2018a).

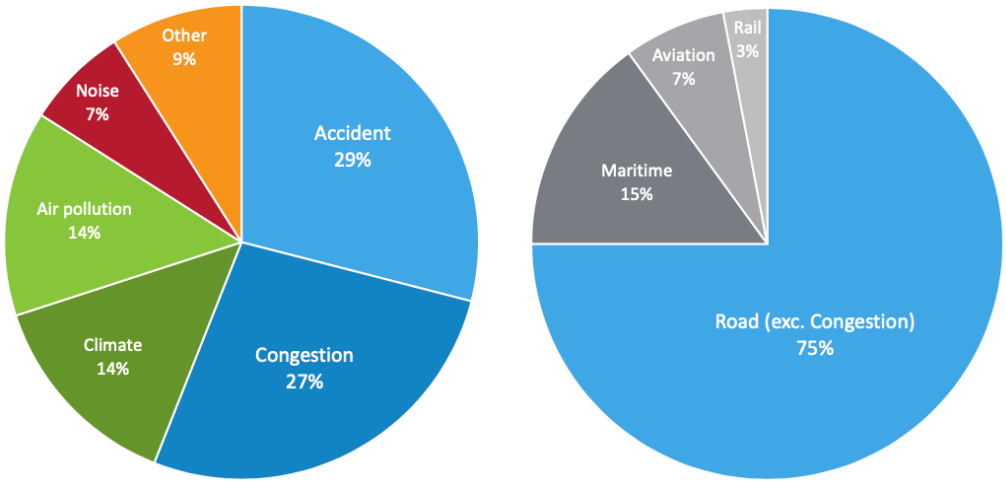


Figure 2: External costs by cost category and by transport mode for EU28 in 2016
Source: European Commission (2018)

Three fast-moving trends promise to disrupt road transport in coming years as summarized in Table 1. Shared mobility is however seen as the most effective solution for reducing car usage and its impacts. Electrification, on which many hopes are based, would in comparison have no impact on congestion, road accidents, physical activity levels and space consumption. The benefits of automation and connectivity still largely uncertain.

Table 1: Disruptive technologies potential

	Shared mobility • Reduce car impacts (ownership, distance, emissions, noises, accidents) • Increase walking and cycling, which are the most sustainable modes (consumption of natural and economic resources, social equity) • Increase road infrastructure efficiency (vehicle occupancy rate) • Increase urban space productivity (greater economic value added)
	Automation and connectivity • Lowers cost by cutting out drivers (could increase car usage and congestion) • Reduced risk of human errors (positive impacts on accidents) • Optimization of road network usage (potential congestion reduction) • Increase urban space productivity (potential decrease in parking)
	Electrification • Emissions and noises reduction

Source: condensed information from EC (2019)

1.2 Shared mobility services

1.2.1 Definitions

Shared mobility is a blurred concept that can be widely extended to all modes and transport services other than driving its own vehicle in single possession. It is a continuum of modes and services ranging from traditional public transport services to brand new scootersharing system.

Shared mobility is not a new concept. The first mention of a carsharing system dates to 1948 when a housing cooperative in Zurich (Switzerland) began a small car share arrangement. More ambitious projects of vehicle sharing systems have seen the light of day in France and the Netherlands in the 1960s and 1980s but lasted only a few years (Chibok, 2018; PBOT, 2011).

Shared mobility services re-emerged slowly at the end of the 1990s powered by the deployment of internet, mobile telephony, and big data. These technologies are today largely inseparable from the concept and will also define the next generation of on-demand mobility services from an operational point of view. Technology is also an important premise of peer-to-peer (P2P) business models, where a private digital infrastructure (e.g. Uber, Airbnb) allows small holders of capital to make a profit within the market of the sharing economy.

The lexicon of shared mobility is evolving rapidly with new business models and the advancement of information and communication technologies (ICTs). This section rules on the terms that will be used in this report based on the terminologies that seemed to be the most consensual now through literature and practices. The way of writing the terms also varies considerably, for example: "bike-sharing", "bike sharing" or "bikesharing". For the sake of simplification of keyword search, we have chosen the last option, removing all spaces and dashes throughout the report.

1.2.2 Typology of services

Shared mobility is a multidimensional concept as summarized in **Table 2**. The market can be divided into two main types of shared services: vehicle rental systems and seat rental systems. In both cases, individuals can have access to the service in exclusive mode (e.g. taxi), and have the vehicle for themselves and their companions, or in shared mode (e.g. ridepooling) with unknown people heading into the same direction. The operational characteristics of the systems then offer greater or less spatial and temporal flexibility. High flexibility generally comes with a reduction in the certainty of accessibility. The last dimension concerns the business model, namely whether the service is provided by a public operator, a private operator or even an individual.

ICTs have been important game changers for the last three dimensions (spatial and temporal flexibility and business model). Global Positioning Systems (GPS), big data and mobile phone have played a major role in commercializing free-floating systems. Decentralized digital platforms have created virtual marketplace for P2P exchange, moving the provision of transportation services away from the traditional B2P model. B2B practices are also expected to evolve in the coming years. Private mobility providers are

increasingly offering related services such as data analysis, booking and billing services. For example, since the agreement between Uber and SAP Concur, receipt from trips taken flow directly into a company's expense reports (Uber, 2020). In the Netherlands, the company Floow2 has developed a platform enabling companies to share their unused resources (e.g. equipment, conference rooms or employees). We can suppose that such a concept could be extended in some ways in a shared mobility ecosystem in the future. Microtransit services have existed for many years in less densely populated areas through a basic telephone reservations system (STM, 2020). The development of algorithms however improved efficiency of on-demand services, including ridesourcing (e.g. Lyft).

Table 2: Typology of services

Dimension	Characteristic definitions
Services type	**Vehicles rental (V)**: cars, bikes, or scooters. **Seats rental (S)**: public or private operator's vehicle or a private vehicle made available through a third-party application.
Using type	**Exclusive (E)**: only one person can use it at a time. **Collective (C)**: several persons can use it at the same time.
Service model: spatial flexibility	**Station-based (SB):** vehicles are available at fixed points in the city. The system can force the vehicle to return to the point of origin (roundtrip) or allow the return to a different station (one-way trip). The second provides a better multimodal flexibility to the user but requires rebalancing operations. Stations can be physical (dock) or virtual (geofencing). **Free-floating (FF):** vehicles can be used freely within an area through a GPS system that locates available vehicles. Such system reduces the walking distance to the destination point. In return, there is however no guarantee that vehicles will be available nearby at the origin point. May cause illegal parking problems in urban spaces that can be partly solved through geofencing.
Service model: temporal flexibility	**Scheduled (SC)**: vehicles run on a planned schedule. The ride is completed regardless of the demand at that point in time. **On-demand (OD)**: supply adapts to demand in real time. The itinerary would not exist without a demand at that point in time. **Reserved (RE):** system forcing or offering the possibility to users to guarantee their trip in advance, can be combined with the two previous options.
Business model	**Business-to-peer (B2P) / Business-to-Business (B2B):** public or private operator providing services to individuals or businesses. **Peer-to-Peer (P2P):** individual providing a service to another individual using his private vehicle.

Source: Chaire Mobilité, Polytechnique Montreal

Table 3 presents the main shared mobility services that will be discussed in this report. Local variations to those services will not be specifically discussed (e.g. scootersharing systems on university campus). Some observation can be made regarding the characteristics. All rental vehicles come with exclusive use, while seat services are part of collective systems except for taxi and ridehailing. New shared services are distinguished by the great flexibility they offer both spatially and temporally. Transit is distinguished by the fact that it is the only system operating independently of demand (except for on-demand transit services usually provided through taxi). Carsharing is the type of shared mobility showing the greatest diversity of models.

Table 3: Shared mobility services, definition, and characteristics

		Service type		Using Type		Spatial flexibility		Temporal flexibility			Business model	
Shared service	Definition	V	S	E	C	SB	FF	SC	OD	RE	B2P	P2P
Public transport / Transit 	Bus, tram, streetcar, metro, trolley, light rail, and trains.		x		X	X		X			x	
Microtransit (taxibus, dial-a-ride) 	Van or bus connecting transit stations or employment centers, based on regular stops or on-demand pick-up location.		X		X	X	X		X	X	X	
Carpooling (ridesharing) 	Cost-sharing practice between a driver and passengers sharing the same journey.		X		X	X	X			X		x
Car rental 	Vehicles available at centralized rental points during office hours only.	X		X		X				X	X	
Carsharing 	Vehicles available in self-service around homes and offices at all time.	X		X		X	X		X	X	X	X
Taxi 	Door-to-door services with a professional driver.	X		X		X	X		X	X	X	
Ridehailing / ridesourcing 	Taxi services provided on P2P basis through a third-party app and which cannot be hailed on the street.		X	X			X		X			X
Ridepooling (ridesplitting, ridesharing, shared ridehailing, ridesourcing) 	Same as ridehailing but where platform optimizes route to maximize car occupancy rate by carpooling.		X		X		X		X			X
Bikesharing 	Bikes or e-bikes available in self-service around homes and offices.	X		X		X	X		X		X	
Scootersharing 	Scooter or e-scooter available in self-service around homes and offices.	X		X		X	X		X		X	

Source: Chaire Mobilité (Polytechnique Montréal). Note: see definition of acronyms in table 1. Note: Some of the icons come from the Noun project site. They were produced by the following artists: Corpus delicti (ridepooling), Jared Ostdiek (ride-hailing), Priyanka (carsharing), Rihards Fromuls (microtransit), JejenJuliansyah (bikesharing), Arthur Schmitt (carpooling) and sketch icon (scooter).

Figure 3 illustrates this idea of a service continuum using two dimensions, namely the type of service and the temporal flexibility. We thus better understand the different trade-offs that an individual faces when he chooses a mobility option within an integrated ecosystem beyond the preponderant questions of time and price of the services. The figure also shows that a large part of recent innovations in shared mobility concerns car-related services or mobility. For the private sector, these services require little capital investment to enter the market and lower sunk costs if they exit. A pedestrian is placed in the center to remind people that walking is both a necessary condition and a direct consequence of greater use of these shared modes.

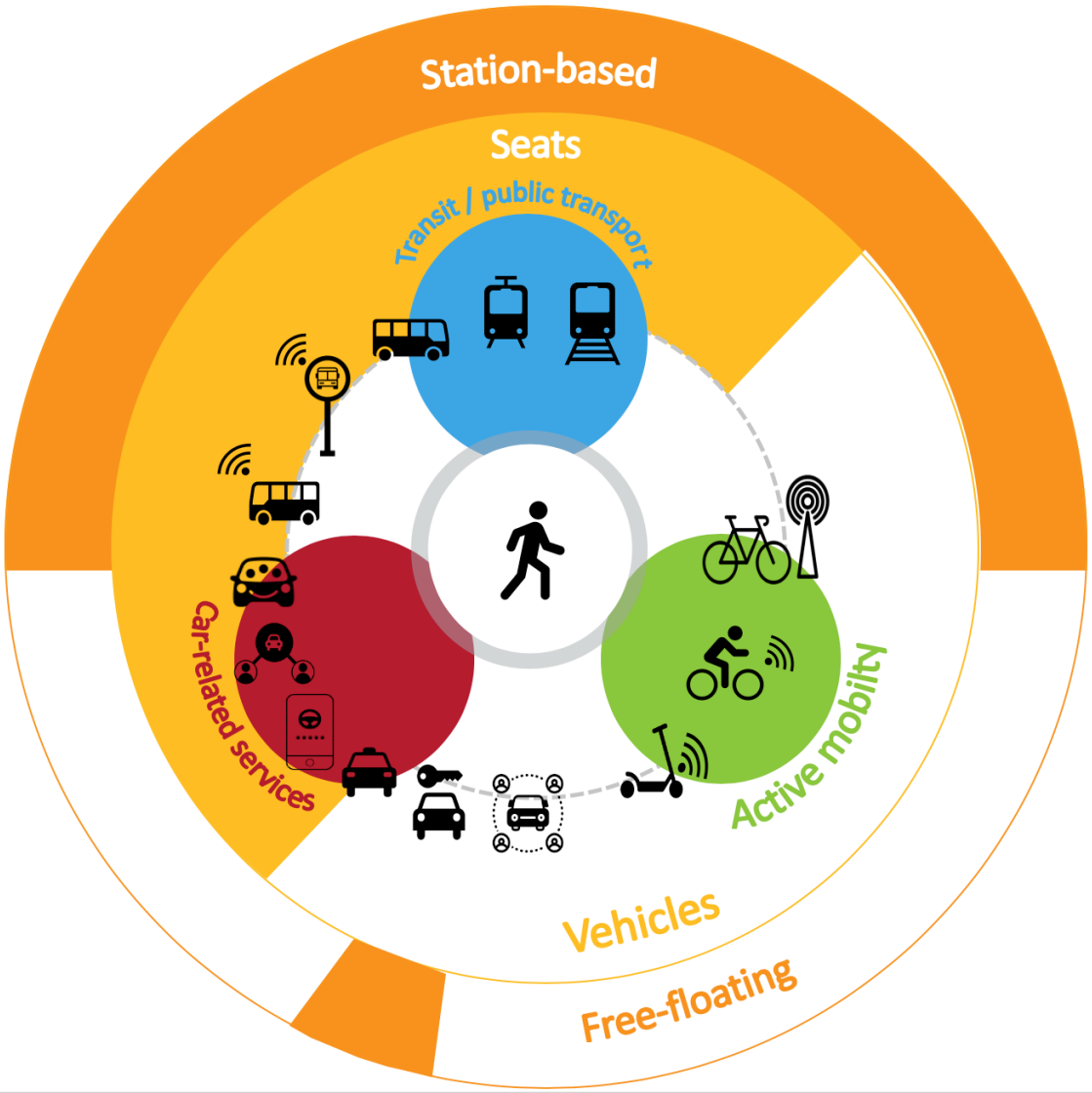


Figure 3: Shared mobility services continuum
Source: Chaire Mobilité (Polytechnique Montréal). Note: Some of the icons come from the Noun project site. They were produced by the following artists: Corpus delicti (ridepooling), Jared Ostdiek (ride-hailing), Priyanka (carsharing), Rchards Fromuls (microtransit), JejenJuliansyah (bikesharing), Arthur Schmitt (carpooling) and sketch icon (scooter).

1.3 Service integration

1.3.1 Definitions

The re-emergence of shared modes of mobility in the 1990s was accompanied by a paradigm shift in favor of a combination of services instead of a strict modal shift between two modes. The objective is now to reduce the share of distances travelled by individual cars, measured by vehicle-kilometers traveled (VKT). In this context, the reduction of the automobile ownership is also central to prevent the propensity to use the car. To achieve this goal, key players in the mobility sector insist on the importance of allowing individuals to switch from one mode to another seamlessly, because the automobile is generally not bothered by any administrative, geographic or financial barrier once the tank is full.

Different terms have been proposed to describe this idea of multimode usage:

- **Intermodality**: based on the definition proposed by Jones et al. (2000), it designates the use of several modes of transport during a single trip to move people or goods.
- **Multimodality**: refers to the use of different modes of transport by the same person at different points in time. It can also designate the availability of several modes of transport in each place (e.g. multimodal station). Multimodality can be seen as a broader term that encompasses intermodality.
- **Comobility**: term proposed by the European Commission, designating the effective use of different modes of transport individually or in combination. This term is opposed to single mobility or single mode, where only one mode of transport is used for all a person's trips (EC, 2006).

The three terms are used interchangeably in the literature as synonyms. In Quebec, the term "**transportation cocktail**" has also been proposed as a synonym to describe a multimodal package of services. The term "**micromobility**" has a completely different meaning however and refers to low speed mode (scooter, bicycle, skateboard, etc.).

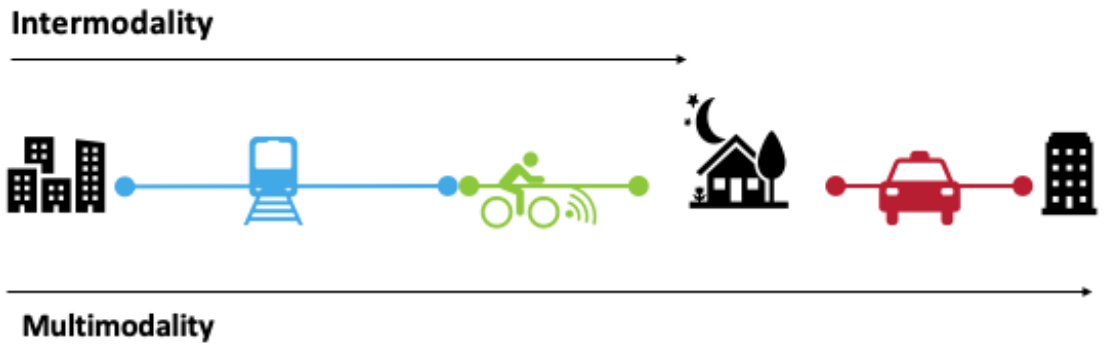


Figure 4: Multimodality and intermodality
Source : Chaire Mobilité (Polytechnique Montréal)

1.3.2 Trip chain concept

A trip chain is composed by the primary activity trip (work, study) and all the secondary activities trips (grocery, daycare, gym) grafted around this primary activity during a day. A trip chain starts and ends at the home location. With this in mind, we can better understand why an individual, who needs to do his groceries on the way home from work, could be tempted to choose the automobile to go to work if he has access to a private automobile. This modal choice may seem more practical for this individual considering all the activities of the day.

The analysis of mobility behaviors of people aged 25 to 44, using data from the 2003 Origin-Destination Survey in the Greater Montreal Area (GMA), indicates that approximately 22% of the daily trip chains are complex (meaning they are composed by more than just one round-trip), with an average of 3.5 trips on an average fall day. The presence of children is a determining factor in the occurrence of complex chains. Women and people with private vehicles tend to display complex trip chains. The three factors hence show some correlation (Valiquette, 2010).

Shared mobility can give more flexibility and allow an individual to use an automobile only for the portion of his trip chain where he it is necessary to (to transport goods for instance), as illustrated in Figure 5.

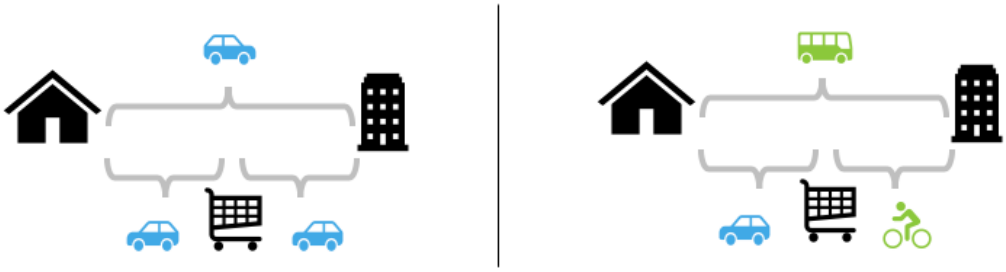


Figure 5: Potential theoretical impact of shared mobility services on a complex trip chain
Source: Chaire Mobilité, Polytechnique Montréal

1.3.3 Modal choice determinants

Several cities base their sustainable mobility strategies on new disruptive technologies. But, despite all the investment, modal share of car remains high. It is not that potential is not there. Morency et al. (2017) estimated (based on a sequential process using trips reported during the 2013 OD survey) that 5.2% of daily motorized trips (427,813 trips) could be made by walking and 19.4% (1,605,244 trips) by cycling in the Greater Montreal Area in 2013. Some important components of modal choice may be overlooked in the process, preventing this potential from materializing.

As illustrated in Figure 6, flexibility and trip planning information are only two components of the modal choices. The factors documented in the literature can be classified into three main spheres of influence on mobility behaviors: the characteristics of the individual and their households, the attributes of the built environment and the features of the trips and transport options.

Modal choices are not cast in stone. They are the result of a larger context. They can easily change according to weather conditions, the time of day or traffic conditions. More importantly, it must be observed how the spheres influence each other. Built environment determine not only the competitivity ratios of transportation modes but also the human experience. Pleasant walking and cycling conditions are the most basic requirement for any strategy aimed at increasing the use of shared mobility. A built environment that smartly takes into account trip chains and physical abilities of individuals makes life easier for individuals, changes their perception and encourages desired mobility behavior. Single component strategies (e.g. mobile app) are less likely to be successful compare to a more holistic approach. Governments have an important role to play in network and location planning (affordable housing strategies, economic development, location of public buildings, tax incentives, investments in infrastructure). As simply summarized by Janette Sadik-Khan, former New York City's transportation commissioner, "you get what you build for".

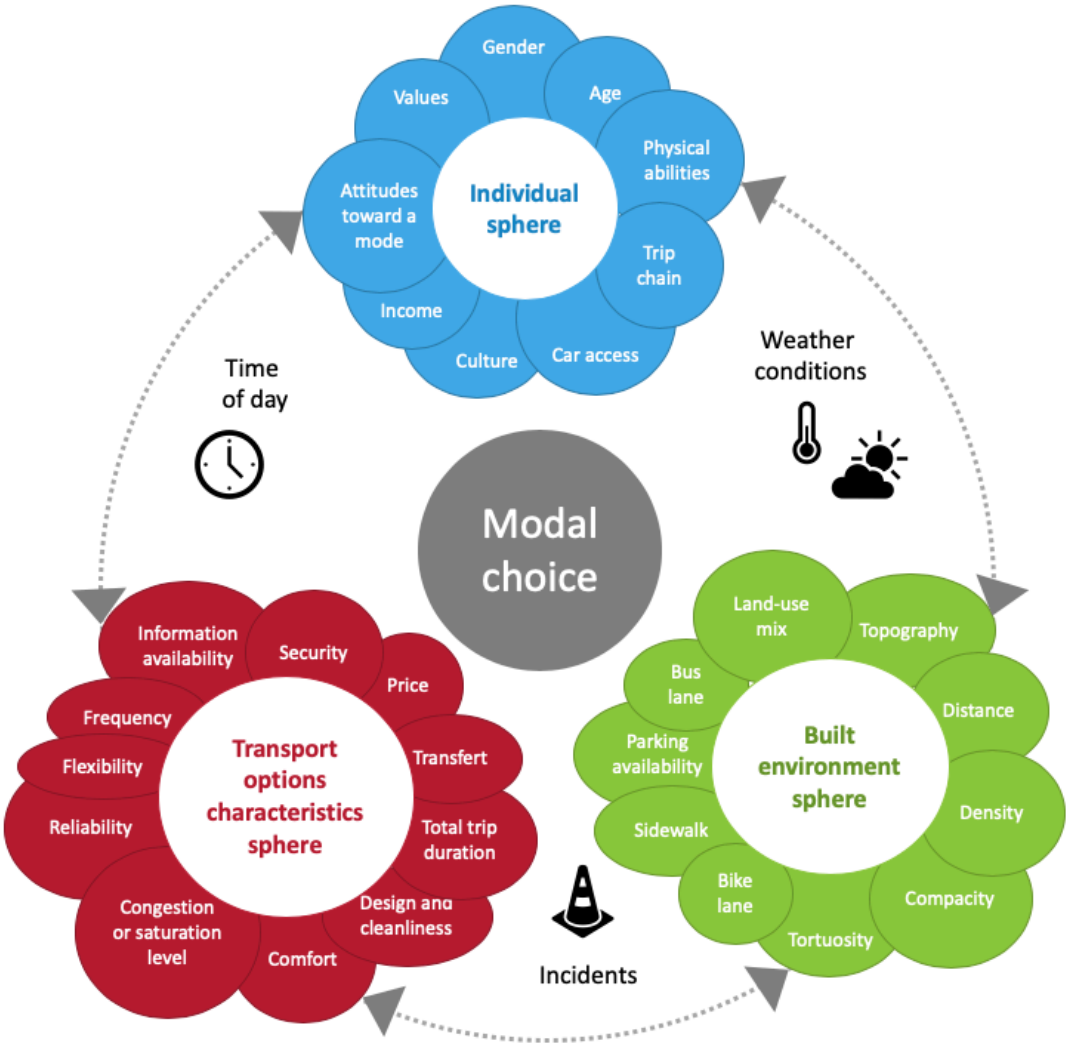


Figure 6: Modal choice determinants
Source: Chaire Mobilité (Polytechnique Montreal)

As illustrated by **Figure 7**, transportation modes form a trade-off continuum in space. If shared mobility services have a huge potential for medium distances, transportation options however become more polarized between car and public transport (PT) as distance increases. Since time is a non-renewable resource in a person's life compared to money, people will choose the automobile even if it is more expensive. This is especially the case for recurring trips. For districts far from the city center, creating built environments allowing the use of active modes for local activities and fast public transport infrastructure for longer trips can help support sustainable mobility goals.

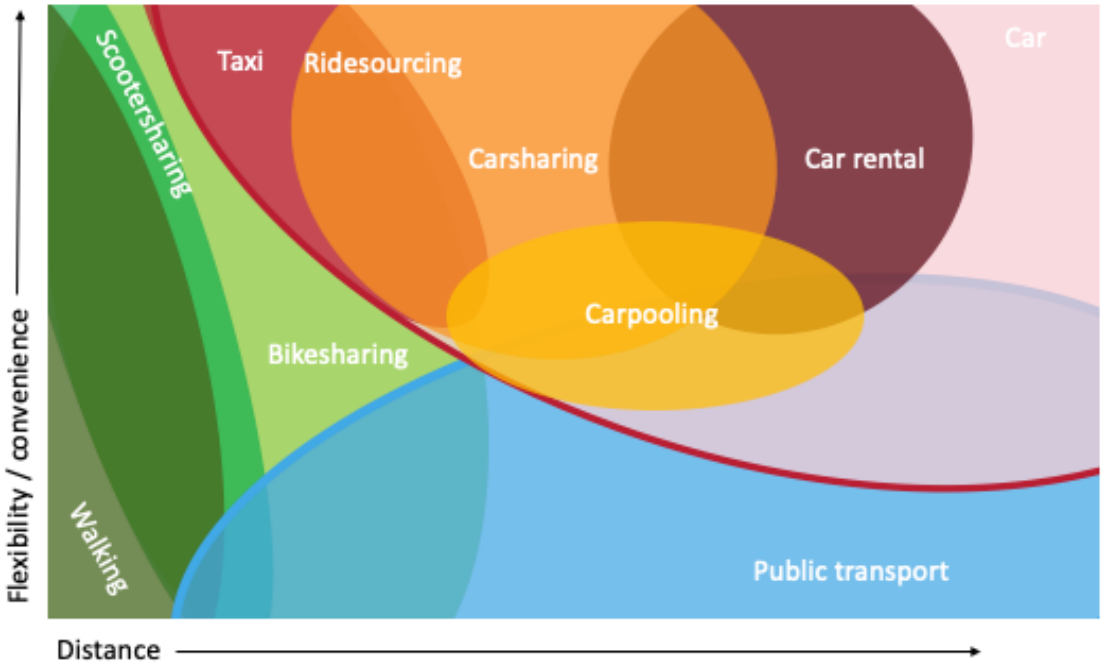


Figure 7: Modal choice trade-offs between distance and convenience
Source: Chaire Mobilité (Polytechnique Montreal) inspired from various publications, including Wagner and Shaheen (2016)

Beaulieu et al. (2018) identify leverages to induce changes in mobility behaviors:

- car restriction policies (e.g. fuel tax, parking fees, parking space removal);
- increase in public transportation services (e.g. dedicated lanes);
- investments in infrastructure facilitating walking and cycling;
- shared mobility services availability;
- information and communication technologies (ICTs) in support of multimodal trips (real time information).

1.3.4 Competitiveness and complementarity of shared mobility services

A scientific literature review concerning the impacts of shared mobility services has been carried out and can be found in Appendix A. The objectives were to document:

- the capacity of each shared mobility services to reduce car use, in terms of car ownership and distance traveled (VKT);
- the level of competitiveness and complementarity between these modes;
- the value added of shared mobility services for certain type of trips, namely commuting, first-last mile connection to mass transit, suburb or low patronage area, night trip, downtown congested area and long-distance trips.

Table 4 summarizes our understanding of the literature results and ground practices.

Table 4: Summary of findings regarding shared mobility literature and expert review

	Rail	Bus	Microtransit	Carpooling	Carsharing	Car rental	Taxi	Ridehailing	Ridepooling	Bikesharing	Scootersharing
Multimodality and its goals											
Multimodality											
Car ownership reduction											
VKT / emission reduction											
Intermodality											
Bus											
Microtransit											
Carpooling											
Carsharing											
Car rental											
Taxi											
Ridehailing											
Ridepooling											
Bikesharing											
Scootersharing											
Trip type											
Commuting											
First-last mile connection											
Suburb / low patronage											
Night											
Downtown/congested area											
Long distance											

Source: Chaire Mobilité (Polytechnique Montréal) based on the literature review in appendix A.
Legend: green = yes, red = no, yellow = uncertain / depend on the context / occasional

All shared mobility services contribute to the adoption of multimodal behaviours especially in the long run as users become aware of new travel options. Shared mobility increases travel flexibility as it can fit a variety of users, various trips (OD pairs), complex trip chains, diverse trip purposes, group travel, travel at various times of the day and day of the week, and, in complementarity, be adapted for various weather conditions throughout the year.

However, they do not contribute in the same way and proportion in achieving multimodality objectives as well as reducing car ownership, vehicle kilometers travellers, GHG emissions and other negative impacts. Taxi-related services have perhaps the most mixed impacts since they tend to be used more occasionally but are often the only available option for some trips. The results depend not only on the frequency, but also on the mode which would have been taken otherwise (and on the availability or not of other alternatives). The impact on VKT essentially depends on the alternative mode that would have been taken otherwise to accomplish this trip.

Carsharing, particularly station-based systems, has a great potential for car ownership reduction among car-related services, according to the literature (see appendix A for a complete review). Not having direct and easy access to a car encourages a more careful analysis of the different options available and a wiser use of the car when reserved. Ridehailing users do not seem to possess fewer vehicles than their non-user counterparts. As they are relatively expensive services, they can hardly fulfill recurring needs of transportation such as commuting except for a well-off segment of the population. Carpooling and ridepooling services, as cheaper options, have more potential to increase the vehicle occupancy rate and the efficiency of road network, but it must be kept in mind that they can have detrimental effect on the financial sustainability of other modes and increase congestion. New scootersharing seems also to be mainly used for leisure and tourism and would largely replace walking (see also appendix A).

Regarding intermodality, shared mobility services can complement or compete each other depending on the context of the trip. Active modes and car-related services tend to be strictly rival within the same category. indeed, It is unlikely that an individual will transfer from a bikesharing system to a scootersharing system within the same trip or from a carsharing system to a taxi service. Transit services tend to be more complementary in this regard. The rail and subway services generally form the backbone of the network, while bus and microtransit services give the local access as a first and last mile connection. Only rail services (e.g. metro, light rail train, train) demonstrate the potential to complement all the other modes. Although the potential exists, bus services are more likely to be substituted by other modes in practice. The combination of active modes or car-related services with transit services seems to be a more interesting alloy in terms of intermodality. Probably because they both benefit from their complementarity.

The last part of Table **4** presents the shared modes that are typically used for certain types of trips. A lot of different modes and systems compete in the downtown area. Conversely, alternatives to the automobile are lacking for suburban trips, the low density making it as difficult shared systems than it is for transit to operate at low cost. In Canada, long-distance and commuting trips are also areas for which there are few alternatives to the automobile in practice, existing options typically having much longer travel times.

1.4 Online tools and mobile apps

Technological innovations have completely changed mobility over the past fifteen years. First, the creation of Google Maps (2004) as a navigation tool greatly contributed to democratize access to roads and public transportation information (namely routes between origin and destination points through general transit feed specification (GTFS) standardization). The appearance of the first touchscreen smartphones, including the iPhone (2007) and Android (2008), as well as data plans, have redefined the whole concept of mobility. Today, most mobility providers have their own online tool and/or mobile application. Consulting all platforms separately to choose the best mobility option became a complex and time-consuming task.

The private sector did not take long to respond to the emerging need for integrated information. Mobile applications integrating information from various mobility operators available in an area have appeared worldwide since the end of 2000s. The first generation of these applications was essentially limited to aggregating, combining and comparing mobility options in order to offer a door-to-door trip planning service (e.g. Google Maps, SkedGo). Applications such as Transit have also contributed to improving the quality of service by making the positioning of vehicles available in real time throughout crowdsourcing methods (SkedGo, 2020; Transit, 2020).

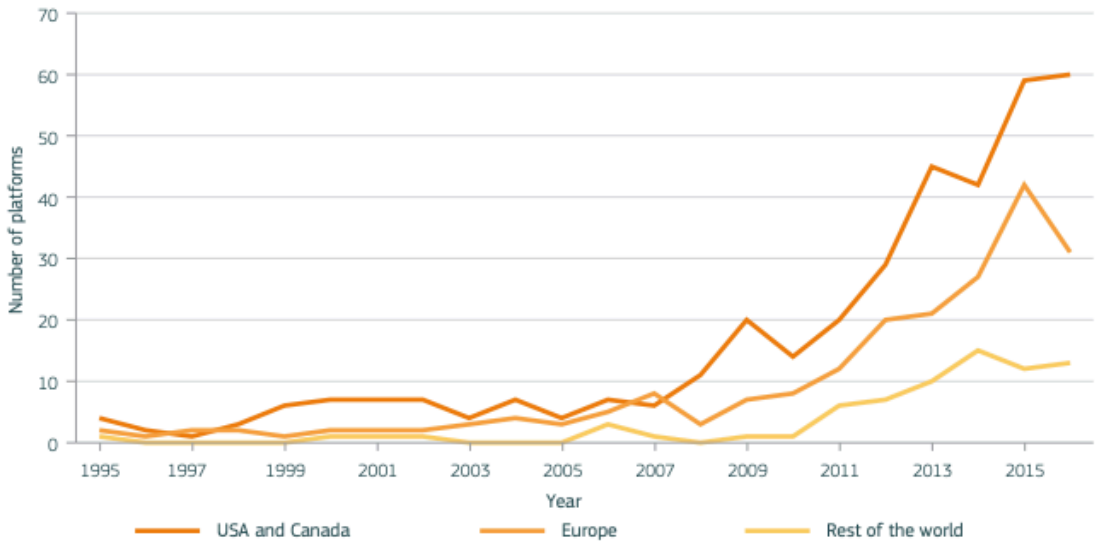


Figure 8: Number of new data-driven transport platforms
Source: EC (2019)

Today's platforms are rather passive. In the future they are expected to play a dynamic coordination role between users and providers that could improve network efficiency. However, once users have a good understanding of the multimodal network, they tend to crystallize their mobility habits rather than systematically consult the available information. Network effects will depend on consumer adoption and participation.

Although the accessibility of information on-route and services is becoming easier, the disadvantage caused by the need to subscribe to multiple services is still present. The

next generation of mobility platform, pushing further the integration of services with a comprehensive purchase plan, is right upon us. This step is however the most difficult to take for many reasons that will be detailed in the next sections. Only one company has stepped up yet. Since 2016 in Finland, MaaS Global Oy (Ltd) offers mobility packages (purchase plans) combining public and private carriers through its app Whim.

Figure 9 proposes a topology of applications inspired and adapted from Sochor et al. (2017). Level 0 “no integration” corresponds to the traditional platform where each operator only displays its own services. Level 1 aggregates several operators, gives information on prices and redirects the user to the sites where he can book and pay. Level 2 allows the user to enter account information with certain transport operators and to book through the application. Level 3 corresponds to the most recent experiments in combining services purchases where the user also becomes a client of the aggregator. In the future, the authors believe that purchase plan could be designed by public authorities to produce the right incentives in connection with the major societal goals (level 4).

Figure 9: Topology of applications
Source: inspired and adapted from Sochor et al. (2017) by Chaire Mobilité (Polytechnique Montréal)

Mobility packages do not have to be linked to a mobile app. In Portland, the transportation wallet aims to reduce the use of cars by residents and workers of the downtown area. The package gives access to the metro, bus, streetcar, bikesharing (Biketown) as well as the e-scooter (Lime, Spin, Bird) services. The program is funded by the surcharge on parking permit (City of Portland, 2020).

1.5 Pricing strategies of shared mobility services

An important characteristic of mobility services which has not yet been discussed concerns the pricing strategies of the different transport operators. Public operators are not subject to the same profitability requirements as private operators since they have various social responsibilities. This section outlines the pricing principles that guide each other's pricing choices and highlights the complexity of combining them under the same purchasing plan and financial agreement. The content of this section is mainly based on the writings of Musgrave and Musgrave (1984) and Nicholson and Snyder (2008).

Transport services are "mixed goods", which is a category that falls in between purely private and purely social goods. Unlike a purely social good, transport services are not truly non-rival. As more users are added, the quality of services received by all users from a given quantity supplied declines. Like private goods, it is also possible to exclude some individuals from consuming them. These characteristics therefore leave room for the private sector. Given the importance of transport systems for the functioning of society, the presence of externalities and economies of scale favoring the emergence of natural monopolies, the public provision, either by direct production or oversight, seems essential. When dealing with private or mixed goods, the principles of equity and efficiency in public finance calls for the recourse of user charges (also called tariffs or user fees) (user pays principle). However, choosing the right price is not a trivial question since transportation services are subject to decreasing costs which means the golden rule of marginal cost pricing equalizing marginal benefit leads to a financial loss. Four pricing strategies can be used to cover the deficit or generate profits, as shown in Table 5.

Table 5: Pricing strategies

Strategy	Definitions
Flat rate	One way is to charge a flat rate to all users and to cover the deficit with subsidies from general public taxation (e.g. income tax) or specific environmental taxation (e.g. fuel tax, congestion charge). Given the positive externalities of transit and the negative externalities of cars, the latter strategy has good social acceptance from taxpayer. However, high price elasticity would transfer a large proportion of funding on non-user taxpayers, which would reduce equity, efficiency, and acceptability.
Market separation **(third-degree price discrimination)**	Since different consumers have different incomes and tastes, an equitable solution would call for different rates (ex. senior rates). Reduction of the deficit could be achieved by concentrating excess charges on the less elastic segments of the demand. This strategy encompasses the extended concept of cross-subsidy between two market segments, one profitable and the other loss-making, as is done for intercity coaches.
Two-part tariff **(second-degree price discrimination)**	This strategy involves supplementing a charge per unit of service over a fixed charge (e.g. membership fee). If the deficit with marginal pricing is small and the number of users is large, a low fixed fee may be enough to solve the efficiency problem without requiring general finance.
Perfect price **(First-degree price discrimination)**	If each buyer can be separately identified, then it may be possible to charge each the maximum he or she would willingly pay for the good, extracting all available consumer surplus.

Source: Chaire Mobilité, Polytechnique Montreal

1.5.1 Public operators' strategies

Public transport authorities (PTA) typically adopt a combination of the first and the second strategy. The fare structure is a combination of base fares (also called media) and pricing adjustments for different types of users. The pricing structure must reflect user mix to generate enough revenue to support operations. The revenue-cost ratio target of most transit organizations around the world ranges from 45 % to 55 %, which means operations are subsidized at 50 % (Calgary Transit, 2014).

Table 6: Public transit operators fare structure strategy

Base fare (media)	• Contactless payment options (no adjustment). • **Cash/single ticket** (one-way, roundtrip, ticket books). • **Unlimited-ride pass** (day, evening, weekend, week, month, year).
Fare adjustment	
Distance	• It typically gives access to a given area. For efficiency and equity purposes, price increase with the distance from city center or number of areas crossed. • Some cities offer short distance fares (e.g. Berlin). • Other cities apply purely kilometric pricing (e.g. Singapore).
Equity concerns	• To promote social inclusion and reflect ability to pay, reduced fares (also called concession fares) are offered to different categories of people (students, senior citizens, disable people, unemployed, children, veterans, apprentices). • Some cities offer special pass to tourists, including preferential rates on local attractions, however there is no economic justification for such practice.
Efficiency concerns	• To increase performance, some transport operators set up incentives rates aimed at distributing demand over time (peak overload) or between modes (bus vs metro) (e.g. London). • To reflect the space used, a ticket may also be required for the transport of equipment (e.g. bicycle) or animals. • To increase the adoption rate of mobile app, some cities apply surcharges on tickets purchased at the counter. This practice raises equity concerns.

Source: Chaire Mobilité, Polytechnique Montreal

As an example,

Figure 10 presents the contribution of fare categories to 2013 Calgary Transit Revenue and the related share of ridership.

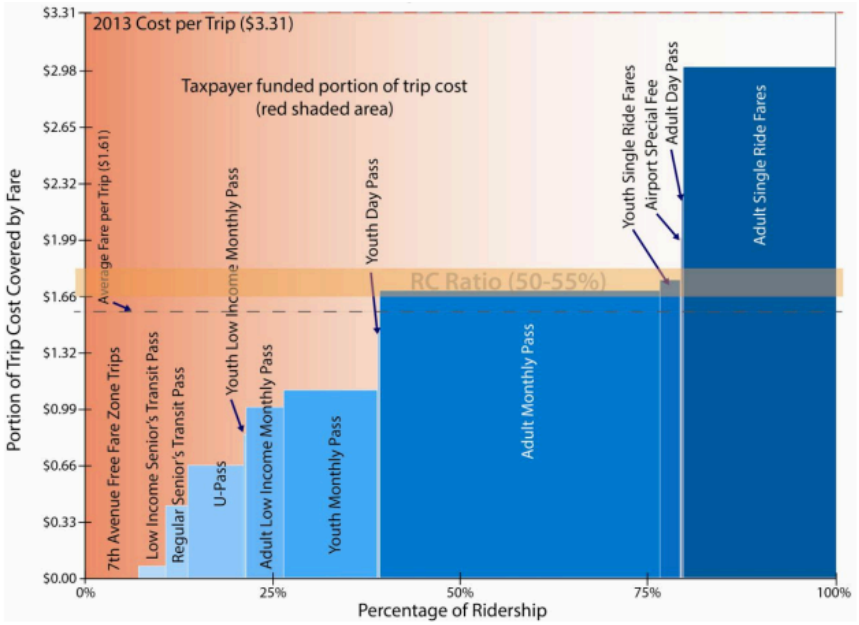


Figure 10: Contribution of fare categories to revenue, Calgary Transit, 2013
Source: Calgary Transit (2014)

1.5.2 Private operators' strategies

Private operators traditionally opt for the third strategy. Linear two-part tariff consists of a fixed fee for the right to consume the service and a uniform price for each unit consumed (time or distance). The operator's objective is to choose the parameters to extract the maximum consumer surplus from a given set of buyers. Different names can be given to the fixed fee (e.g. to start fee, base fare, membership), as illustrated in Table 7.

Table 7: Two-part tariff examples in Montreal

	Traditional taxi rate	Ridehailing UberX	SB-Carsharing Communauto	Scootersharing Lime
Fixed fee	3.50 Start fee	$1.90 Base fare + $2.10 booking fee	$500 $ refundable membership + $40 $/year	$1 Start fee
Variable fee	$1,75 /km + $0.60 $/min	$0.79 /km + $0.19 /min	$3.35/hour or $26.80/ day + $0.41/km	$0.30 $/min
Minimum price	-	$6.80	-	-
Price adjustment	-	Surge pricing, multiplication of the base fare	Weekend surcharge	-

Source: Bureau du taxi de Montréal, Uber and Communauto

However, nothing prevents operators from adopting another pricing strategy, except for the traditional taxi industry. Two-part tariff has been implemented in most cities around the world to regulate the taxi industry, aside entry restrictions and service zones. This pricing strategy allow private operators to generate profit, but it also produces the right incentives. Location decisions have important economic trade-offs for drivers. Flat rate would encourage drivers to refuse long trip as well as those with an origin or a destination in low traffic areas. Conversely, pure distance-based pricing would encourage drivers to refuse short-distance trip and to take detours (Buchholz, 2019).

First-degree price discrimination remained relatively theoretical until recently. Sellers are however increasingly using big data and algorithms to price discriminate among customers and offering personalized price for personalized services. Uber's prices, for example, vary with the level of demand, the geographic region, the time of day as well as the type of vehicle chosen. There is a fine line between a pricing practice which increases the efficiency of resource allocation, in the presence of high demand, and a price abuse resulting from an asymmetry of information. The level of competition in the market is crucial in this respect to preserve competitive prices (Bar-Gill, 2018).

Bikesharing systems owned by public operators tend to have a pricing structure like public transportation, including unlimited season passes for trips under a certain duration (30 minutes for instance). Private company can also adjust their pricing to pursue certain objectives. Communauto, a carsharing company, offers preferential rates for families, short distances, long distances, and business uses as well as unlimited trip plan (each trip is however limited under a certain duration) in exchange of a monthly fixed fee. However, objectives behind those pricing strategies tend to be more commercial than social as for public operators.

1.6 Mobility-as-a-Service (MaaS)

MaaS is still at a very early stage in its development with many ongoing experiments around the world. This section presents a state of knowledge on the subject.

The concept of MaaS emerged alongside this idea of integrating platforms. It is a vision of a transport system that would integrate all information, booking and payment to provide the most convenient, reliable and affordable solution for any trip. This vision also reflects the hope that the sharing economy could leverage the massive unused road vehicle capacity to alleviate endemic congestion problems (ITF, 2019).

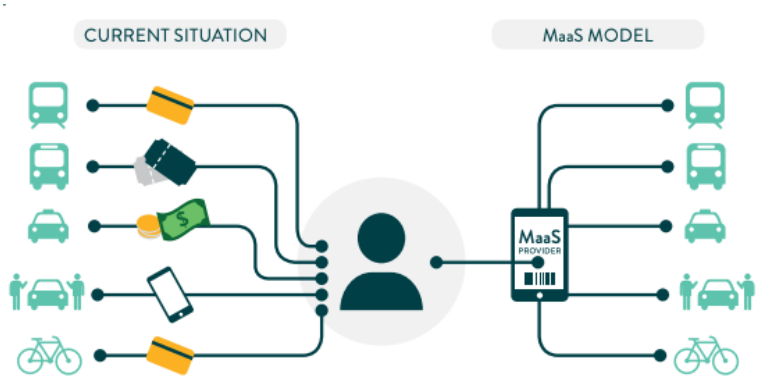


Figure 11: MaaS integration
Source: UITP (2019)

1.6.1 First mentions

The first mention of a concept close to MaaS dates back to 1996 (Whim, 2019). During an International Conference in Innsbruck (Austria), Nico Tschanz and Hans-Dieter Zimmermann raised the issue of information systems that "*hardly assist the traveler if he or she wants to change his or her itinerary*" (Tschanz and Zimmermann, 1996). Thus, the idea of an "intelligent information assistant" to overcome these limitations was envisioned. This assistant would offer multimodal transport combinations based on user's preferences, as well as an integrated payment service and real-time information (e.g. delays).

The term MaaS emerged around 2012. It was used publicly for the first time by Minna Kivimäki, Director General of the Ministry of Transport and Communications of Finland (Whim, 2019). It was also used in a conference entitled "E-Mobility as a Service" in San Francisco (Agrion, 2012). The conference questioned the impacts of future technologies, social medias, and demographic developments on how residents are approaching the way they get around their city. It also questioned the future of car ownership:

> "*The comment that Shelby made about taking your car down to Palo Alto and letting somebody else use it for the rest of the day made me think of something. We are going to have to change our attitude about how we regard our cars. Up to this point in time, a lot of people bought a car and then it became something like a household pet. You are taking a very utilitarian view of the car, where it is out there earning money and it comes back to you. There is going to be a social change here that will alter the emotional attachment we have to the car. Should we look at ownership models of cars not as something to own, but as a service or as a utility?"* – Gerry Tierney

Sampo Hietanen, founder of ITS-Finland and MaaS Global Oy (Whim app), is often considered as the father of the MaaS since he would have been the first to mention the idea of a mobility package in 2006, but mostly because he launched the first MaaS service in 2016. Interest in the concept has been growing since. However, the picture would not be complete without mentioning the involvement of the Finnish government and the city of Helsinki who put in place the necessary regulatory frameworks (TIP Consortium, 2019).

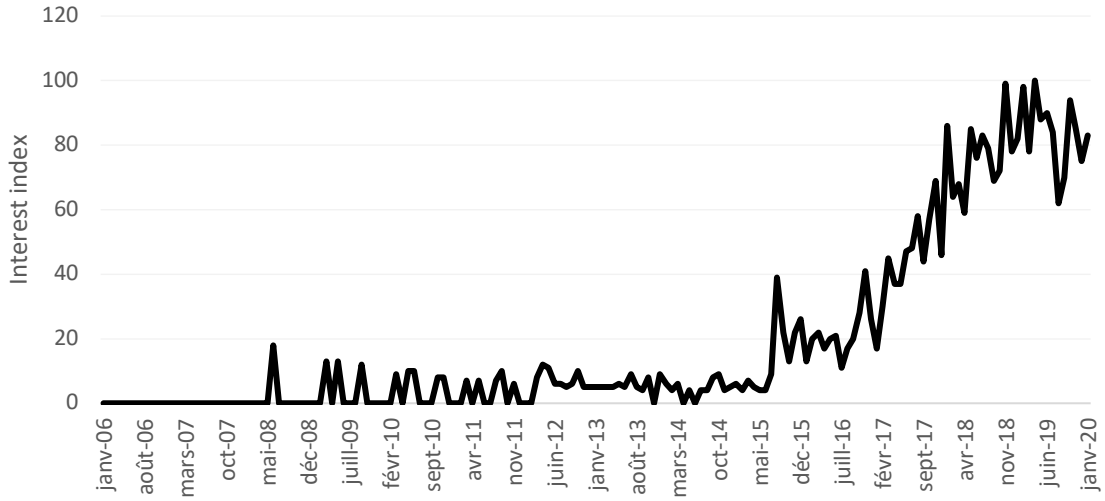


Figure 12: Interest over time for the term "Mobility as a Service" in Google search
Source: Google Trends. Note: Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. A score of 0 means that there was not enough data for this term.

1.6.2 The MaaS Alliance

In 2014, the MaaS Alliance was formed by the **European Road Transport Telematics Implementation Coordination Organization (ERTICO)**. ERTICO is a membership-driven organization promoting, evaluating, and implementing intelligent transport systems (ITS) technologies in Europe through a variety of activities, such as interest groups, innovation platforms, events, and projects. ERTICO was itself founded in 1991 at the initiative of 15 industry leaders supported by the European Commission. Since 1994, ERTICO organizes ITS European and World Congresses. ERTICO partners include 3 mobile network operators, 28 public authorities (transport departments, cities, regions), 23 research centers, 17 service providers (e.g. TomTom, IBM), 12 suppliers (e.g. Panasonic, Mitsubishi Electric), 8 traffic and transport industries (e.g. Michelin, Siemens) and 10 vehicle manufacturers. ERTICO is at the origin of the creation of numerous international forums, networks and associations on specific themes related to safer, cleaner and smarter mobility (ERTICO, 2020).

The **MaaS alliance** is one of these platforms and is also a public-private partnership organization. Its main objective is to facilitate a single and open market as well as the full deployment of MaaS services in Europe and elsewhere. The alliance does not implement projects by itself but promotes the various initiatives underway around the world and connects interested stakeholders. The website notably mentions Transit App as well a Communauto for its mobility package with public transport and bikesharing system (Bixi).

1.6.3 Definitions

There is no consensus on the definition of MaaS, which is also sometimes referred to as "combined" or "integrated" mobility services. In its simplest form, as proposed by the MaaS alliance:

> "*Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand*".

Philippe Crist, advisor at ITF, noted that the variety of definitions used by agencies, academics and industry groups reflect their specific interest on the subject and the service they would like to deliver. It also reflects the variety of models that emerge around the world. The key elements that come up the most often through the definitions, as reported in Table 8Erreur! Référence non valide pour un signet., are:

- **User centricity:** demand-driven, customization and personalization
- **Multimodality:** various modes and combinations of services
- **Open ecosystem:** evolutive concept, multi-actors
- **Single digital channel:** travel information, booking and payment
- **Seamless freedom:** door-to-door services, variety of options and flexible choices
- **Accessibility:** available anytime
- **Usership**: not car ownership, pays-as-you go, cost savings

Table 8: Overview of definition and description of MaaS

Source	*Definition/description*
MaaS Alliance (2020)	(Website, "What is MaaS?") "Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand. To meet a customer's request, a MaaS operator facilitates a diverse menu of transport options, be they public transport, ride-, car- or bike-sharing, taxi or car rental/lease, or a combination thereof. For the user, MaaS can offer added value through use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations. For its users, MaaS should be the best value proposition, by helping them meet their mobility needs and solve the inconvenient parts of individual journeys as well as the entire system of mobility services. A successful MaaS service also brings new business models and ways to organise and operate the various transport options, with advantages for transport operators including access to improved user and demand information and new opportunities to serve unmet demand. The aim of MaaS is to provide an alternative to the use of the private car that may be as convenient, more sustainable, help to reduce congestion and constraints in transport capacity, and can be even cheaper."
A.D. Little (2018), p. 59	"The concept of 'Mobility-as-a-Service' (MaaS) aims to provide consumers with integrated, flexible, efficient and user-oriented mobility services. It implies a shift away from the personal ownership of individual motorised transportation modes, and non-integrated means of transportation towards the use of integrated multimodal mobility solutions consumed as services.

	This shift is enabled by combining transportation services from public- and private-transportation providers through an 'integrated mobility platform' that creates and manages the journey and integrates planning and payment (based on mobility packages tailored to the needs of each customer segment) on a one-stop-shop principle."
Atkins (2015), p. 19	"MaaS can be defined as: The provision of transport as a flexible, personalised on-demand service that integrates all types of mobility opportunities and presents them to the user in a completely integrated manner to enable them to get from A to B as easily as possible."
Ghanbari et al.(2015)	"MaaS, a multi-actor environment that provides seamless door-to-door services for end users by combining several modes of transportation."
Heikkilä, (2014), p. 8	MaaS is "a system, in which a comprehensive range of mobility services are provided by customers to mobility operators."
Hietanen (2014), pp. 1–2	"MaaS is a mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider. Typically, services are bundled into a package."
ITS Australia (2018), p. 20	"MaaS systems offer customers personalised access to multiple transport modes and services, owned and operated by different mobility service providers, through an integrated digital platform for planning, booking and payment."
K2 Swedish Knowledge Centre for Public Transport (2017)	"Integrated Mobility Services mean that in one and the same service, one knits together many ways to move in the city (e.g. carsharing, bus, tram, commuter train, bikesharing, private vehicles) at the same time that one can offer payment of and information about the modes via one and the same interface. These new mobility services contribute to an increased freedom of choice and a reduced need to own a car, especially in larger cities or metropolitan areas." (translated from Swedish)
Kamargianni et al. (2015), pp. 11–12	"The term 'Mobility as a Service' stands for buying mobility services based on consumers' needs instead of buying the means of transport. Via 'Mobility as a Service' systems consumers can buy mobility services that are provided by the same or different operators by using just one platform and single payment."
Karmargianni & Matyas (2017), p. 3	"Mobility as a Service is a user-centric, intelligent mobility distribution model in which all mobility service providers' offerings are aggregated by a sole mobility operator and supplied to users through a single digital platform."
König, Eckhardt, Aapaoja, Sochor &	"Multimodal and sustainable mobility services addressing customers' transport needs by integrating planning and payment on a one-stop-shop principle."

Karlsson (2016)	
MaaS Global (2018)	"MaaS, short for Mobility as a Service, brings all means of travel together. It combines options from different transport providers into a single mobile service, removing the hassle of planning and one-off payments."
MuConsult (2017), p. 4	"MaaS is defined as the range of flexible, partly demand-driven, multimodal mobility services in which tailor-made integrated travel options are offered to travellers via a digital platform." (translated from Dutch)
Mukthar-Landgren et al. (2016), p. 8	"We adopt the term 'integrated mobility service' (IMS) to describe a service that not only integrates a range of mobility services, both public and private, but also provides one-stop access to all services through a common interface (hence creating a seamless customer experience, i.e. the service). The service component could be more or less developed, ranging from simply the possibility to find travel information and pay for different mobility services within one technical system, to providing more far-reaching mobility service offers such as subscriptions to different mobility packages, perhaps also involving other service components such as goods delivery or bicycle repair services."
Samtrafiken (2017), pp. 4, 18	(p. 18) A way of thinking where "mobility is something that can be purchased as a service and does not require owning a private car." (translated from Swedish) (p. 4) Also, "services that facilitate traveling from A to B by different means of transport" … "the services can be anything from a multimodal travel planner to a full mobility subscription. The services can also include transport of goods as a complement to personal mobility. The common starting point is that the services should inspire and attract travelers to more sustainable travel and to reducing private car dependency." (translated from Swedish)
Transport Systems Catapult, (2016)	(p. 6) "The Transport Systems Catapult has defined MaaS as using a digital interface to source and manage the provision of a transport related service(s) which meets the mobility requirements of a customer." (p. 10) "The [mobility] service model is associated with understanding the 'who?' and 'why?' of customers' mobility requirements and only then is the transport solution offered as a 'how?'."
UITP (2011), p. 1	Combined mobility is "carsharing, taxis and shared taxis, bicycle and bike-sharing, car-pooling, demand-responsive transport, car-rental, etc., are services that can complement the classic fixed line-and timetable-bound public transport services and, together with walking, they form a complete and coherent mobility solution." (N.B. private cars are not mentioned as part of the complete solution except for carpooling, i.e. shared use.)

Source: table adapted from (Sochor et al., 2017)

1.6.4 Financial models

Some ideas for financial models have been put forward, but the strengths and weaknesses in the specific case of a MaaS ecosystem have yet to be assessed (UITP, 2019):

- **Merchant model:** operators pay a commission for the reselling of the services.
- **Agency model:** operators agree with MaaS provider on a pre-paid bulk purchases with a volume discount. Profit margin is gained through reselling at normal published rates or at higher-than-published rates.
- **Transactional model:** operators pay fee per click.
- **Mobility bundle:** subscription fee.
- **B2B customer:** service fee for aggregated billing.

Since one of the objectives of MaaS is to reduce the individual ownership and use of the automobile, the application may be partly funded by dissuasive taxes on car ownership (purchase tax, surcharge on parking cards) or on use (toll, parking rate, fuel taxes).

One critical question is to determine who should be the MaaS provider or the "Integrator". Three models have been imagined so far as summarized in Table 9. Considering all the advantages of the public system, this system seems the most logical in the eyes of UITP. But regardless of the model chosen, the experts interviewed for the ITF Masterclass consider that the government should play an active regulatory role.

Table 9: MaaS integrated platform models

	Commercial	Public	Open
Description	Free market where different providers compete and weave agreements with different operators.	MaaS runs under a public transport authority which sets the rules and concludes agreements with operators	Public sector sets an infrastructure on which different actors could build a back-end solution based on APIs data of all mobility services
Advantages	Competition fosters customer-oriented and innovative solutions	PT is the backbone and has the largest customer base, availability of data for planning purposes, packages can reflect public goals, promotes consumer confidence	Costumer-oriented, innovative, and impartial solution, inclusivity of all mobility providers
Disadvantages	Doubts on social inclusivity and data sharing without being legally forced, high risk of bias in the presentation of the transport options, misalignment with public goals, threat of monopoly	Possibility to be less customer-oriented and innovative	Funding options needs to be addressed
Example	Zipster (Singapore), sets by MobilityX Pte Ltd and Toyota Tsucho	Üstra (Germany), first public MaaS worldwide solution	Wienmobil (Austria), Upstream, sets up the digital infrastructure

Source: condensed information from UITP (2019)

1.6.5 Issues

The future of mobility looks very promising. However, certain issues concerning the inherent market structure of transport, the existence of high financial interests and the constraints weighting on businesses must be acknowledged to ensure the founding of a system that will benefit the greatest number.

Unless otherwise stated, the content of this section is based on the observations of experts interviewed during the 2019 ITF Masterclass (ITF, 2019) as well as on the UITP report on MaaS (UITP, 2019) and the European Commission report on the future of road transport (EC, 2019a).

High financial interests

Once in place, the system will certainly find takers, but the desire to set up MaaS systems and financial agreements currently arises from the private sector, more than the population or the government. As pointed out by the European Commission: "*With its EUR 7 trillion annual revenue stream, transport attracts disruptive technology companies that are not interested in preserving the current model in the same way as conventional players may be tempted to. A perfect storm of new technologies and new business models is transforming not only our vehicles, but everything about how we get around and how we live our lives*".

The market is evolving faster than our ability to understand it. Everybody wants to develop the mobility service, the platform or the underlying infrastructure who will succeed in capturing this market. The current situation recalls the Klondike Gold Rush of the late 19th century. Many entrepreneurs enter the market hoping to become the next Jeff Bezos and exit as quickly without having discovered the gold nuggets.

The finish position in this race is important and motivates risk taking in investment. Question of money and habits, it is difficult to get a consumer to subscribe to an additional platform or new services. The first companies on the market therefore usually have a head start against their competitors. Small operators providing complementary mobility services can have a hard time fitting into this transactional ecosystem. Forging partnerships with other operators, with public transport authority (PTA), gives them not only visibility and accessibility to the consumer pool, but also potential guaranteed revenue in case of a mobility packages and credibility with other PTAs.

It is important to note that the profit prospects for mobility services are very low. Even Uber, who is poised to become the Amazon of transportation, is still not profitable and some doubt it can ever be (Forbes, 2019). With its 62 US$bn valuation, Uber had the first ranking position in 2016 Unicorns List of Fortune Magazine, which also include, Didi, Lyft, Ola, GrabTaxi, BlablaCar, UcCar and more recently Lime. A "unicorn" is a start-up that has a valuation, on paper at least according to venture capitalists, of a billion or higher. Some discern and echo of the dotcom bubble. Today Uber' market capitalisation is US$43bn, more than a third below what it was on its first day of trading. Covid-19 shock comes at a time where unicorns were exhibiting health issues. Lime had already laid-off 14 % of its staff and a dozen of cities. One of the important contributing factors of the unicorn bubble would have been the *Jumpstart Our Business Startups (JOBS) Act* adopted by the American Congress in 2012. The measure was designed to encourage

small business funding by easing various federal regulations, particularly by allowing start-ups to receive small individual contributions (crowdfunding). But it also gave the possibility to increase the number of shareholders while remaining private and therefore not to have to disclose certain information. According to *The Economist*, complex, shaky, and opaque financial structure are one of the most important problem that afflict most of the unicorns. On average, firm would be overstating their valuations by 48 %. Several mergers and acquisitions are expected in the coming months, particularly between competing companies (e.g. Uber and Lyft). Tech giants (Alphabet, Amazon, Microsoft, and Facebook) could also take advantage of the situation to make acquisitions that would, in normal circumstances, be prohibited by the government.

An important commercial value lies in the data beyond the transportation services. This partly explains the interest of car manufacturers to invest in the MaaS ecosystem as they have an exclusive access to the data generated by their vehicles. A concept that would be incompatible with the principle of fair and undistorted competition according to the European Commission.

From our point of view, one element is worth noting:

- For a mobility package, the design of the funding agreements is crucial to generate the right incentives of the various stakeholders and users. MaaS concept is sometimes described as a non-competitive bundling of services, but public budgets and market shares are in their essence financial cakes which can lead to undesired competitive practices.

An international competition for local markets

For many companies, cities constitute a test bench for services and platforms that are aimed to be replicated internationally. In Finland, the Whim company announces that it will cover intercity and international travel in the future. Once an app has been adopted, consumers will preserve their habit while travelling. Although it is possible for several applications to coexist, it is a race with commercial interests at local, national, and international levels. The market reality is evolving towards national or even global MaaS (or multi-local but on a global level). These global/multi-local players will mostly address non-frequent trips, but the size of that market segment should not be underestimated.

For the moment, companies compete fiercely on what this platform should look like. The current market is very prolific in innovations that benefit the consumer. Some observers wonder what role public authorities should play in preserving the market open and competitive in the future as local markets are increasingly subject to global movements.

Data governance and market failures

The aggregation of services within the same platform makes it easier for consumers to choose the shortest or cheapest option. However, the trip planner algorithm must remain independent. Data aggregation on the supply-and-demand side of the market gives large platforms a better market overview than individual operators. This market power can be used to affect individual transport decisions based on extended business interests who can go beyond transportation sector. This observation raises many questions as to the

objectives pursued by the platform, the protection of personal information as well as the data governance.

To our understanding, there are other key elements to consider:

- It cannot be excluded that a highly capitalized company could undercut the prices of its services in the short term to get its competitors out of the market and then increase its prices to the detriment of the consumers on some corridors. This is the strategy used by Amazon which inspired Uber in particular. The market situation must be monitored closely to safeguard the public interests in the long run.
- Most governments are sorely lacking information regarding real time travel data and will not be able to validate if platforms direct consumers towards the best choices for them or towards the ones that provide a profit to the platform owner. Obtaining data is essential.
- The lack of data can also make it difficult or impossible to judge the fairness of the prices offered to consumers.

Undefined goals and needs

This idea of combining several services comes at a time when little is still known on consumers' needs about shared mobility services and multimodality. For the moment, the main selling point of MaaS concept is its greater convenience for the consumer, which is a good thing because the shared mobility ecosystem must become more efficient to compete with the automobile and convince more people to adopt sustainable mobility habits. It should be recognized that equity issues are not so much present in the discussions on MaaS at this point.

Experts stress the importance for governments to focus on people needs, then to define their national and local objectives and regulate the industry accordingly. As summarized by ARUP: "*The private sector can add mobility choices to the market — sometimes in partnership with the public — to help this target be attained; however, a net result that includes increased inequities or deprivation should not be accepted as a product of progress*" (ARUP, 2018). The gains in reducing GHG emissions in the long term, but also the risks of loss in terms of accessibility for people with physical and / or financial limitations must be assessed carefully. The central governments must also ensure that the local governments have in their hands the necessary tools to monitor the market.

Diversion from public transport system

We also have little information on the complementarity and competition links between the different shared mobility services. Opinions are very divided on the capacity of MaaS to produce the desired changes in mobility behaviors. On the one hand, it can be assumed that offering greater accessibility to carsharing, taxis and ridesourcing services could reduce the necessity to own a car. On the other hand, concerns are expressed that this greater accessibility will create more congestion and come at the expense of public transport systems in three ways. First, a diversion of PT ridership in favor of car-related services would lead to a decrease in its revenue, which is widely considered as already insufficient. Second, road congestion would further reduce bus competitiveness. Third, in a tight budgetary context, this could encourage the government to transfer his responsibility to the private sector, to disengage from the necessary investments by

thinking that new technologies will allow the market to meet demand without a structuring transportation network. It is important to remember that most of new mobility services companies have never made a profit until now. The commercial viability in the long run of the model is still very uncertain. Also, as pointed out in the next section, it does not seem to fill the mobility gaps as much as we would hope it did. On the contrary, operators tend to tear the downtown market apart, which leads to a difficult financial situation for all. There is an urgent need to better understand the overall demand for transport and the needs of the population to create a market that will be beneficial for the government and private partners.

Transit is considered as the spinal cord of the MaaS ecosystem by both public and private key players of the MaaS industry. High quality public transport is essential to provide an affordable alternative to car ownership and fulfill most of the trips, along with walking and cycling, by using urban space more wisely. New services cannot reach these targets alone. According to UITP, public transport authorities must remember they have a very strong position in setting up MaaS conditions as a “must-have”.

Another word that is not so much present from current discussion on MaaS is therefore prioritization. As discussed in the next sections, most of the new shared mobility services are convenient for occasional usages, while PT is the backbone of a sustainable mobility routine. Much emphasis is placed on technology, while basic infrastructure is still lacking, especially in the suburbs. As summarize by the European Commission:

> “*New technologies alone will not spontaneously make our lives better without upgrading our transport systems and policy. Early evidence suggests that transport efficiency is not necessarily improving. New mobility solutions such as car sharing, ride sharing and ride-hailing services are making cars even more appealing, thereby luring passengers from public transport, which is often perceived as old, dangerous, and uncomfortable. As a result, several cities, especially in the USA, are experiencing a significant increase in road congestion. If the introduction of automated vehicles makes car-based transport cheaper and even more comfortable, the situation will deteriorate further. At the same time, flexible options may remain out of the reach of the more price-sensitive segments of the population unless they are well integrated into the public transport system.*”.

The research team also wants to point to the following elements:

- While the benefits of public transportation have never been so praised, many cities have seen their transit ridership plateaued, if not decreased these last years. Much ink has been spilled to explain this trend and try to find solutions. If low gas prices and interest rates favoring the purchase of a car have been pointed out, it seems that weak investment in public transit systems also played a big role. Boisjoly et al. (2018) explore the determinants of public transport ridership from 2002 to 2015 for 25 transit authorities in Canada and the United States. Results demonstrate that vehicle revenue kilometers (VRK) and car ownership are the main determinants of transit ridership. Results suggest that decision-makers can act by improving their bus service through investments in their operations, while limiting increases in fares. The study also highlights the importance of policies that discourage car ownership and promote multimodality. It would be however not recommended to

divest from transport and land-use planning responsibilities and let the market regulate itself. This is a path followed by some Canadian provinces since the late 1990s, leaving cities the sole responsibility of public transportation while they do not have the financial and technical resources to carry out this mission. The trends observed regarding car ownership rates and distances traveled are very heavy and distance us from our GHG emissions reduction objectives. It is important to support the public transport authorities (PTA) financially, but also to adopt urban development practices and house ownership strategies that will allow PTAs to steadily reduce their operating costs and increase their income. Such a vision requires collaboration between the three levels of government: the federal government responsible for the national housing strategy, the provincial government responsible for transportation, and the municipalities responsible for land use planning. The initiatives of the European Commission to federate all the actors on its territory constitutes in this respect a source of inspiration.

- We can suppose that the gains of MaaS will be greater in central cities where city dwellers need an occasional access to a car to transport goods, go faster to an appointment or make intercity trips. Although accessibility to the automobile through shared mobility services may divert some occasional journeys from public and active transport and cause some households to be partially motorized when they would not without these services, they also have the potential to slow down the complete motorization of households. It must also be seen as a social contribution since it allows some households to access a car at a much lower cost than owning one and contributes to improve their quality of life. The whole question remains, however, for suburb residents for whom the use of the car is not occasional due to the structure of their neighborhoods and the distances they must travel to reach main destinations. The main challenge will be to convince suburban residents to adopt these new services (as they do not seem so keen to use services such as carpooling for their commute trips) and not only to let more providers tear apart the downtown market with diminishing marginal benefits. In the suburbs, mobility trends are sometimes so severe that they cancel out the gains of the city centers. More efforts must be made to understand the needs of this segment of population. Not only in terms of mobility, but also for housing, jobs and family obligations, since all these activities are linked in the household daily trip chain (discussed in section 1.3.2). Hence, we must make sure that the new developments account for travel needs of households and facilitate adoption of more sustainable behaviors.

1.6.6 MaaS ecosystem

If we synthesize the results of the literature, pilot projects, and expert opinions, the winning conditions for setting up a successful MaaS ecosystem would be:

- Clear social goals aligned with population's needs;
- Strong transit system surrounded by valuable mobility providers;
- Good quality infrastructure and urban context providing comfortable riding, walking and cycling conditions;
- Wide accessibility to the internet, Wi-Fi and mobile phones;
- Regulations leaving space for the private sector to invest, but preserving market competitiveness and driving innovation;
- Active monitoring, planning and funding from public sector;
- Strong intergovernmental collaboration and data governance with reciprocity and transparency in data sharing agreements as well as standardisation guidelines and cybersecurity.

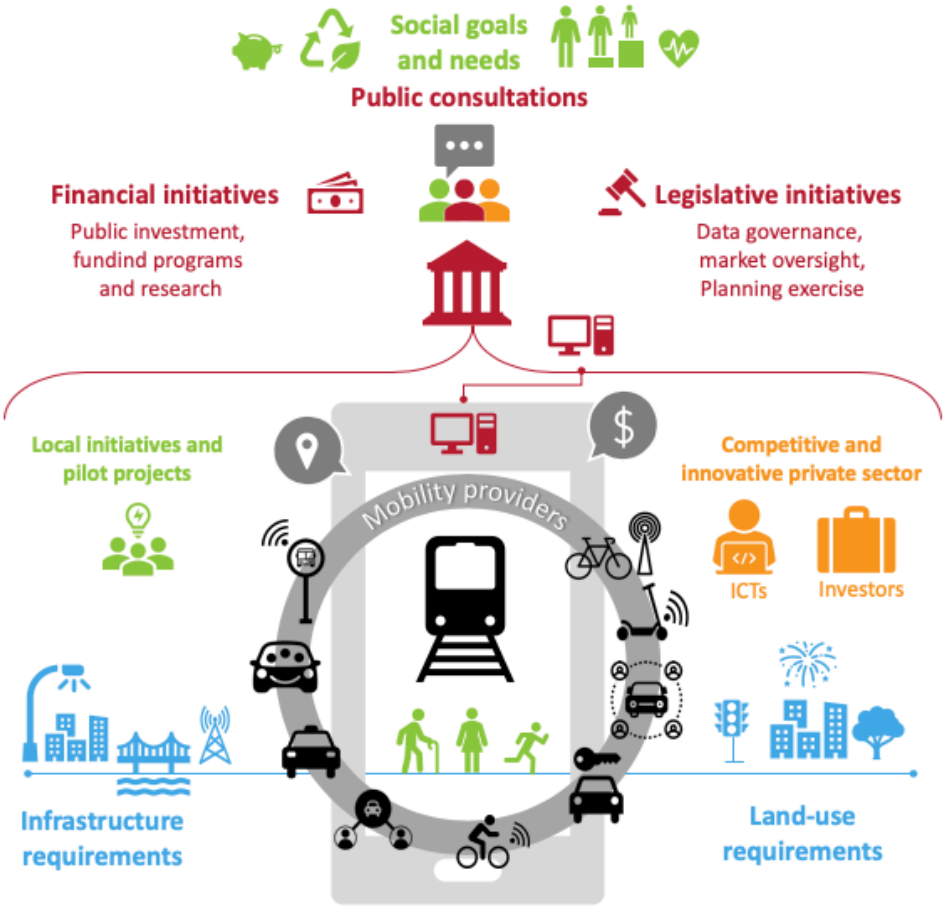


Figure 13: Successful MaaS ecosystem
Source: Chaire Mobilité, Polytechnique Montreal

2 Case studies

While mobility issues are primarily local, Transport Canada is a federal organization in a country where transportation is a shared legislative responsibility. An overall vision of the national context within the country regarding transportation will help better understand the role Transportation Canada can play in supporting shared mobility strategies. For each of the countries selected, the case of at least one city is further analyzed to document the context of implementation of the shared mobility services.

2.1 Selection methodology for countries and cities

2.1.1 Countries

Transport Canada provided an initial list of countries for which to obtain a portrait of shared mobility services (Netherlands, Australia, Singapore, Sweden, South Korea, Finland, and Denmark). To validate the list of countries under study, we propose to analyse the trends in greenhouse gas (GHG) emissions and passenger car ownership since the 90's. This analysis will perhaps make it possible to highlight the efforts of certain countries to achieve greater transportation objectives, as Canada aspires to. The data used come from the Organization for Economic Co-operation and Development (OECD), as well as official national statistics organizations.

Wealth is an important predictor of car ownership. Available data, at the international level, indicates a strong correlation between national wealth and motorization rates (Figure 14). Between 1995 and 2015, a catch-up effect in motorization rates can be observed in Eastern Europe (Estonia, Latvia, Lithuania, Poland, and Slovak Republic) as well as in Korea. Some of these countries even display higher motorization rates today than other countries with a similar level of wealth in the past (inflation and purchasing power differences considered).

However, a general slowdown in car ownership levels and a decrease in the correlation with GDP can be observed in the most developed countries. The International Transport Forum (ITF) looked at the long-term trends in personal car usage. Experts note a slowdown in the growth of mobility (measured in passenger-kilometers) which they attribute to the aging of the population, the slowing down of demographic growth, the intensification of urbanization and new mobility services and a cultural shift among younger generation. The reasons for this decline are not yet fully understood. Among the explanatory factors, mention is made of the evolution of mentalities, in particular in favor of ecological values, changes in lifestyles, including the desire to start a family at an older age, as well as relatively less advantageous economic and employment conditions than previous generations which would constrain automobile access. Understanding these new trends is, according to the experts, essential for adjusting public policies consistently with environmental objectives (ITF, 2014). It can also provide information on the sustainability of business models and the growth of the market for shared mobility services in the future.

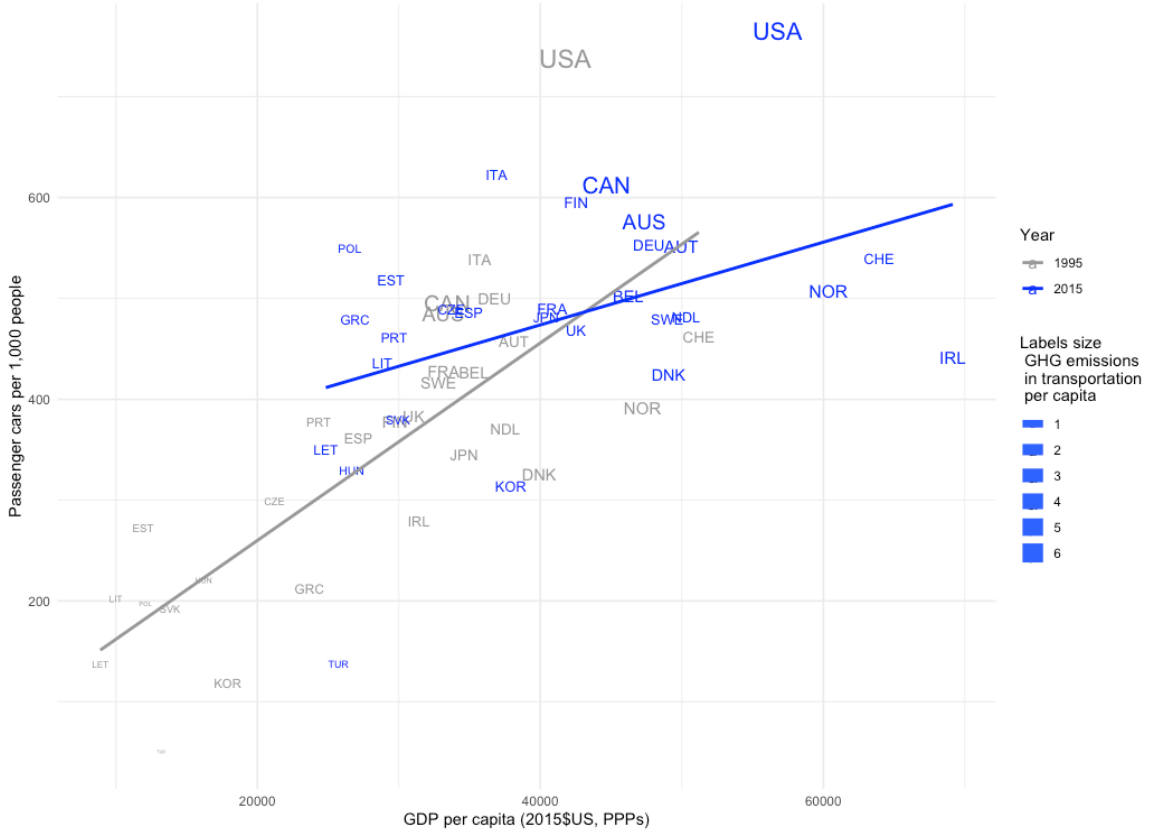


Figure 14: Passenger vehicles and GDP per capita, OECD countries, 1995 and 2015
Source: OECD Stats, Natural Resources Canada, EuroStat, US Bureau of Transportation Statistics and authors' calculations. Note: Four countries were excluded because data of the year 1995 were not available and could not be approximated (Chile, Israel, Mexico and New Zealand) as well as Luxembourg which was an important outlier and hampered the readability of the graph. Data from Italy for the year 2015 is an average of the years 2014 and 2016. GHG emissions include the entire transport sector (road, air, sea and rail). To maintain comparability over time, US data includes the following categories: passenger cars, light duty vehicle short wheelbase, light duty vehicle long wheelbase (includes large passenger cars, vans, pickup trucks, and sport/utility vehicles with wheelbases larger than 121 inches) and other 2-axle 4-tire vehicles. Certain vehicles used for commercial purposes may therefore be included. As an indication, the inclusion of light and medium trucks for the transportation of goods in Canada add up to a maximum of 15% of vehicles to the fleet of light passenger vehicles.

Regarding its level of wealth, Canada is the country with the highest car ownership after the United States. The countries with a comparable level of wealth but a significantly lower car ownership that could be of interest for this study are Korea, Japan, Norway, Denmark, Sweden, the Netherlands, France, Belgium, Ireland and the United Kingdom. With a lesser difference in terms of car ownership, Finland, Germany, Austria, Switzerland, and Australia.

The United States, Canada and Australia emit more GHG emissions in transportation than most European countries despite a comparable level of wealth and car ownership (Figure 15). The intensity of use of the automobile must be considered beyond possession, and this is perhaps where shared modes take on all their importance. Among the countries with significantly lower levels of GHG emissions in transportation per capita and which could be of interest for this research: Japan, Italy, Sweden, Switzerland, the United Kingdom, Germany, France, and Denmark.

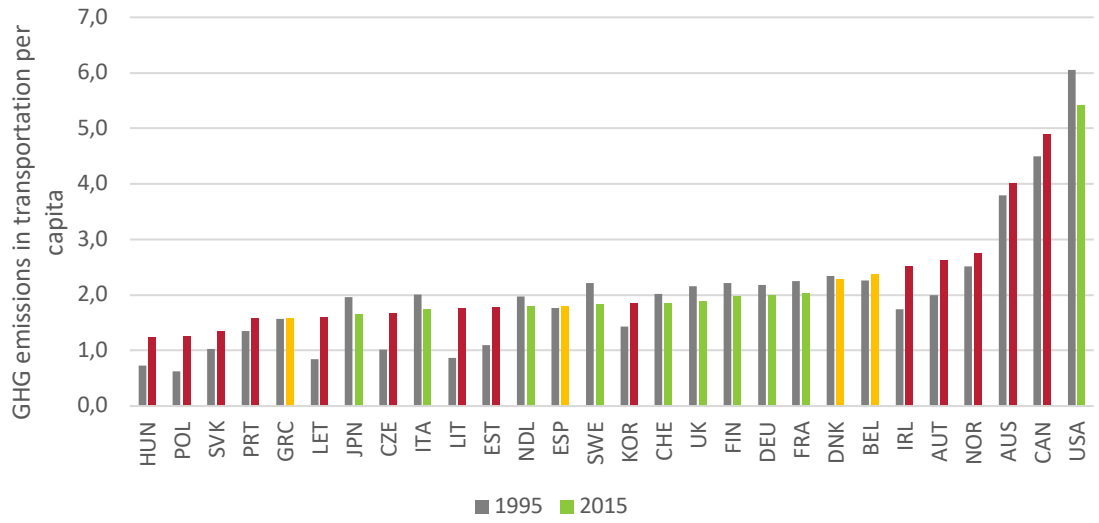


Figure 15: GHG emissions in transportation, per capita, OECD countries, 1995 and 2015
Source: OECD Stats and authors' calculations. Note: Green = Decreasing GHG emissions, Yellow = Stable, Red = Increase.

A final criterion to consider in selecting countries for analysis of their public systems and policies is the structure of governance. Canada is a federal state, which means its legislative powers are divided into three different units (federal government, provincial governments, and municipalities). In this type of state, as discussed in the next sections, the relationship between the federal level and the municipalities is not as close and direct as in unitary states. Other federal states which could be of interest are Germany, Australia, Austria, Belgium, United States, and Switzerland.

The final list of countries under study is presented in Table 10:

Table 10: Selected countries

Criteria	Initial	Motorization	GHG	Federation
Singapore	X	NA	NA	
Denmark	X	X	X	
Finland	X	X	X	
Netherlands	X	X	X	
Sweden	X	X	X	
Australia	X	X		X
Korea	X	X		
Germany		X	X	X
Japan		X	X	
Switzerland		X	X	X
France		X	X	
UK		X	X	
Austria		X		X
Belgium		X		X
Ireland		X		
Norway		X		
Italia			X	
USA				X

Source: Chaire Mobilité (Polytechnique Montreal)

2.1.2 Cities

Cities were selected on the basis of special mentions by the MaaS Alliance and the UITP as well as the indicators as presented in Table 11, which include: Singapore, Seoul (Korea), Tokyo (Japan), Berlin (Germany), Copenhagen (Denmark), Amsterdam (Netherlands), Stockholm (Sweden), Vienna (Austria), Helsinki (Finland) and Sydney (Australia).

Without surprise, the cities chosen are either the capitals or the most important economic poles within their country. While it would have been interesting to document smaller cities, larger cities provide a better view of overlapping shared systems. The choice in Sweden was the most difficult since Gothenburg was also a very interesting candidate. Stockholm was ultimately chosen because its sustainable transport modal share (public transit, biking, and walking) was higher.

Several other countries and / or cities were considered through the process. Including Switzerland, London, Vienna, Paris and Oslo, The city of Vienna was finally chosen as the 10th case study whereas it has the highest modal share for sustainable transport and also for its mobile application, WienMobil, which allow to book and pay for public transport, bike- & car-sharing, taxi service and parking garages. The city of Oslo (Norway) figures among the international rising stars to track in the coming years due to its ambitious GHG emission reduction targets.

Table 11: Selected cities

	Passenger cars Per 1,000 inhabitants	Public transit Vehicle-km per capita (VKM)	Public transit passenger-km per capita (PKM)	Daily trips per inhabitants	Modal share of sustainable transport modes (%)
Singapore	116	84	2659	2,5	68
Seoul	271	NA	NA	2,4	NA
London	307	168	2841	3,1	60
Tokyo	329	106	5684	2,5	69
Berlin	339	130	1968	3,0	69
Copenhagen	360	143	2246	NA	NA
Amsterdam	371	NA	NA	NA	NA
Stockholm	389	144	2482	2,5	56
Vienna	390	99	1733	2,7	72
Helsinki	391	108	1909	3,0	NA
Paris	414	84	2497	3,4	61
Oslo	450	99	2091	2,8	52
Munich	452	106	2825	3,4	62
Hamburg	452	98	2196	2,9	48
Goteborg	453	98	2196	2,7	39
Geneva	467	58	1017	NA	58
Zurich	484	84	2189	NA	51
Sydney	500	50	1155	3,5	NA
Montreal	573	50	1140	2,3	NA
Brisbane	624	50	721	3,0	16
Rome	641	67	2856	2,0	40

Source: UITP, Mobility in cities database, 2015

2.2 Differences among cities

Before comparing shared mobility services, let us quickly review the demographic, economic, territorial, and constitutional differences among selected cities. The populations and areas presented in this section do not correspond to the traditional measures reported by cities, regions, or countries. It is based on EU-OECD's Functional Urban Areas (FUA) definition. According to the OECD, urban area comparisons requires to overcome the administrative definition of territories and to consider the continuity of the built-up area within a metropolitan region as well as commuting behaviors. FUAs therefore encompass the economic and functional extent of cities based on daily people's movements (Dijkstra et al., 2019; OECD, 2013, 2019a). To provide more context to the comparison, data from Toronto and Montreal have been added.

2.2.1 Demographic

Although the most important city of each country has been selected, the demographic differences remain significant, especially with Asian cities. Tokyo metropolitan area is indeed 23 times more populous than Helsinki (Table 12). There is however a greater homogeneity between European cities. The demographic weight of these cities represents, on average, 20% to 30% of the national population. Singapore is a notable exception as a single and sovereign city-state. At the other end of the spectrum, with only 6,3 %, Berlin is still the most populous city of Germany, but the country has a very large number of cities of the same size. Seoul region represents almost half the population of Korea. According to OECD, there are significant regional disparities between the Seoul region and the remaining of the country, particularly regarding access to services and education (OECD, 2016a). Almost half of young people aged 14 and under in Korea live in the Seoul region. Copenhagen and Vienna also seem to attract young families. Japan faces a very aging population. The old-age dependency ratio, corresponding to the ratio of elderly people (aged 65 or older), an age when they are generally economically inactive, compared to the working population, is 10 percentage points above other cities.

Table 12: Demographic indicators, 2016

City (state, region)	FUA's Population (million)	Demographic weight in the country (%)	Population growth (2000-2016)	Share of national youth pop. (%)	Old-age dependency ratio
Helsinki (Finland)	1,5	26,8	1,1	27,8	24,0
Copenhagen (Denmark)	2,1	36,0	0,7	36,6	25,5
Stockholm (Sweden)	2,3	23,0	1,4	24,8	24,2
Amsterdam (Netherlands)	2,7	16,0	0,6	16,1	24,0
Vienna (Austria)	2,8	32,5	0,9	32,6	26,3
Sydney (New South Wales, Australia)	5,0	20,9	1,4	20,8	20,0
Berlin (Berlin Land, Germany)	5,1	6,3	0,3	6,3	30,3
Singapore (Singapore)	5,6	100,0	2,1	12,3	17,1
Seoul (South Korea)	24,0	46,9	1,1	47,2	15,3
Tokyo (Japan)	35,4	27,8	0,5	27,1	37,2
Montreal (Québec, Canada)	4,4	12	0,9	12,6	25
Toronto (Ontario, Canada)	6,9	19	1,3	19,8	21,6

Sources: OECD, Metropolitan eXplorer, World Bank Data and Department of Statistics Singapore

2.2.2 Territory

Asian cities are at least 4 times denser and built-up area per inhabitants is half the size of other selected cities. Singapore stands out clearly, the gross density is 26 times higher than in Berlin and the built-up area per inhabitant 10 times smaller than Sydney. This difference in built-up area includes smaller spaces dedicated to living and working, but also to motor vehicles and parking. Denser cities, generally, display a lower motorization rate and greater use of public transport. Public transport services are relatively more developed in Stockholm, Copenhagen, and Berlin. The number of public transport vehicle kilometer traveled (VKM) in those cities is 3 times more important than Sydney. The density of public transport demand in Tokyo relative to the size of its network supply is considerably higher than all the other cities studied.

Amsterdam is by far the densest European city, but the motorization rate is higher than in Copenhagen and Berlin. Amsterdam has implemented some of the most car restrictive policies in the last years. City policies are consistent with the public transport level of service, the more abundant the supply is (both urban and interurban), the more restrictive are the policies. Curb street parking is capped by district. New constructions in the city center are not entitled to any parking permit whether they have access to private parking spaces or not. The number of street parking spaces will also be reduced by 10,000 spaces in the coming years.

Cities of the same density can have a very different shape, depending on the height, size, proximity and mix of buildings. Berlin has a density and a built-up area proportionally similar to Helsinki. Its territory is however larger and its "core area" occupies a smaller proportion of its territory. According to OECD definition, a “city core” consists of a high-density cluster of contiguous grid cells of at least 1,500 inhabitants per km^2. This implies that outside the core center of the Berlin metropolitan region, there is remote built space areas economically connected to the core. Still, the development plan of the city of Berlin indicates its intention to stop scattered settlements and fragmentation (OECD, 2012). In Tokyo, the core area represents 64% of the FUA.

Table 13: Territory (2014) and mobility (2012) indicators

City	Gross density (pers/km2)	Land area (km^2)	Core area (%)	Built-up area (m^2 per capita)	Public transit (VKM per capita)	Public transit (PKM per capita)	Passenger cars (per 1,000 inhab.)
Berlin	295	17 453	6,2	216	130	1 968	339
Vienna	304	9 180	4,5	297	99	1 733	390
Helsinki	314	4 688	16,6	209	108	1 909	391
Stockholm	321	7 070	19,6	160	144	2 482	389
Sydney	406	12 400	16,0	334	50	1 155	500
Copenhagen	568	3 619	12,6	265	143	2 246	360
Amsterdam	821	3 311	35,2	293	NA	NA	371
Tokyo	3 123	11 329	64,0	124	106	5 684	329
Seoul	3 594	6 691	49,7	55	NA	NA	271
Singapore	7 797	722	NA	35	84	2 659	116
Montreal	359	12 140	13,4	281	50	1140	573
Toronto	436	15 808	20,6	263	NA	NA	NA

Sources: OECD, Metropolitan eXplorer and UITP, Moblity in cities database

2.2.3 Land-use planning

The concept of compactness has acquired an important place in sustainable development practices in recent years. This approach promotes a more parsimonious approach to space and resources. According to the OECD, a compact city is not only dense, but it also has close-up building patterns, has efficient public transport links, and offers a mixed environment that provides access to local services. In 2012, an OECD study on compact cities shed light on practices in certain cities and countries (OECD, 2012).

- Although Sydney has one of the most spread out urban area, it is the most compact urban form among Australian cites. The New South Wales (NSW) government aims to locate at least 70% of new homes pithing the existing urban areas and 80% within walking distance of public transport.
- Some countries give incentives to locate density near public transportation routes. In Austria, housing subsidies are linked to density requirements. The Vienna region has also extended its green belt in the past years to encourage densification.
- The City of Stockholm implemented a comprehensive urban plan from the 1950s following the idea of "Building city inward", that is to say that the city limits were set at the beginning in order to promote a thrifty use of available space and brownfields redevelopment. The plan also promotes the development of complete neighborhood (land use mix) and high-density housing close to PT stations. It is estimated that 95% of Stockholm residents live near a transport node. The City has also implemented congestion charges on vehicles entering the city center.
- In Japan, strong motorization growth and the development of suburban shopping centers have led to problems like what is observed in North America: a decline in the central population, vacant stores, unused land, and decay of local communities. The urban revitalization plan at the end of the 1990s intend to requalify these spaces. The aging of the population has also led the central government to get involved in development plans to ensure livability in the urban area. A study conducted in Japan also shows that compactness policies make it possible to reduce greenhouse gas emissions. For example, Meabashi City and Kochi City are similar in term of population and territory size, but the higher dependency on vehicle in Meabashi and the lower density result in 40% higher annual CO_2 emissions per capita in the transport and logistic sector. The revised Kyoto protocol Target Achievement Plan has been revised by the government to promote low-energy environment and foster low-carbon urban and regional society through urban renovation and concentration of urban facilities and to put them within walking distance.
- Seoul established a greenbelt in 1971 to stop excessive urban expansion and loss of open space. Despite this, due to its strong population growth, Seoul is struggling with major congestion problems and a severe lack of housing. The most recent development plan provides for densification of urban areas, but also the development of ten multi-modal transfer centers linking public transport to the bicycle.

2.2.4 Economy

GDP is the standard measure of the value added generated through the production of goods and services in a territory during a certain period. The value of production in Stockholm is 1.7 times higher than Seoul per inhabitant (Table 14). Seoul and Copenhagen are important economic engine within their country as the share of their GDP represent a bit less than half of the national production value. The two cities host a significant proportion of working age population. The difference in GDP can be explained by several factors, including the value of the goods produced on international markets. Some observations concerning the economic structure of the selected cities are:

- Korea has experienced one of the strongest economic growth in recent years, which has allowed it to rise among the high-income economies. However, its economy is still largely based on manufacturing activity, despite massive investments in the ICT sector. In 2015, Korea was the 6th largest exporter in the world. The slowdown in world trade since 2010 has been especially detrimental to Korea, as exports account for nearly 60% of total demand (OECD, 2016a).
- In Stockholm, like other Nordic cities, the public sector is a major employer. The city has several important universities and research centers. Stockholm, so as Copenhagen, is also considered as a front runner in green economic growth. Early infrastructure investment such as building the city's metro system in the 1950s, and development of district heating following the 1970s oil shocks has helped to build today's lower carbon economy (EC, 2020; LSE, 2013).
- Singapore ranks as one of the top financial services centers in the world. While the city-state was among the third world countries just a few decades ago, its business-friendly regulatory environment reform and education system investment made it one of the most popular investment hubs and richest nations in the world. Today, 40 % of its workforce are foreigners (HSBC, 2020).
- Berlin's economy had been structurally weak for many decades due to the Cold War, but the city is now showing one of the most significant growth among Europe. Low real estate prices and alternative culture, however, make it an ideal place for start-ups. Berlin is also an important economic center for the transport, mobility, and logistic sector. It hosts the headquarters of Deutsche Banh, Bombardier, and Siemens. Tesla is also planning to build a gigafactory in the region.
- Due to its position along waterways and close to the North Sea, Amsterdam has always been a city highly focused on international trade. It is still a global hub for air, road, water, rail, and information transport. Schiphol airport generates an important share of the economic activity. A recent study commissioned by the City Community of Amsterdam and the Chamber of Commerce also finds that approximately a third of the firms in the metropolitan area is involved in one aspect or another of sustainable development. Amsterdam has also the largest ICTs hub in the Netherlands and the largest internet hub of the world: the AMS-IX (Tieben and Smid, 2013).
- Helsinki rose to the top of the Fortune Magazine list in the early 2000s thanks to its education system, quality of life, security, but also for its adoption of new technologies. In 2000, it obtained the highest ratio of Internet connections and the second rank, behind Stockholm, for the density of computers. The ICT sector employed 59,000 people in 2000, particularly in telecoms and data processing activities (OCDE, 2003).
- Tokyo region is Japan's leading industrial center. Automotive companies are among the largest employers in the area (Toyota, Nissan, Honda, Mitsubishi).

Table 14: Economic indicators, 2016

	GDP per capita (USD)	GDP per capita Growth (%)	GDP share of national value (%)	Working age pop share (%)	Equivalized household income (USD)	Passenger cars per '000 inhabitants
Seoul	35 202	2,3	47,1	48,0	21 882	271
Berlin	37 601	1,3	5,5	6,3	23 241	339
Tokyo	42 551	0,4	32,3	29,3	26 947	329
Sydney	44 930	1,0	20,4	21,4	43 229	500
Vienna	46 787	0,2	35,3	32,8	28 725	390
Helsinki	49 760	0,2	34,9	28,4	29 421	452
Copenhagen	54 258	0,9	42,8	37,0	29 606	360
Singapore	54 764	0,9	100,0	100,0	ND	116
Amsterdam	60 857	1,0	21,0	16,5	29 310	371
Stockholm	61 754	1,6	31,8	24,0	35 822	389
Montreal	35 933	0,5	10,2	11,9	38 802	573
Toronto	44 780	0,3	20,0	19,3	39 408	ND

Sources: OECD, Metropolitan eXplorer and World Bank Data. Note: for Copenhagen and Seoul, the equivalized household income corresponds to the average disposable income of the country.

GDP however falls often short of providing a suitable measure of people's well-being. In Sydney, the average household income is similar to the value of national production, which is not the case for the other selected cities. Disposable income, adjusted (equivalized) for household size, is a better indicator to measure the ability of households to afford a vehicle. However, GDP remains an interesting indicator for understanding the economic pressure that can be exerted on land use. When economy grows and land becomes scarce, prices rise and the space reserved for the automobile, which does not produce added value in itself, tends to give way to more productive uses. There is a complex link between the space available for development, population growth and economic activity.

2.2.5 Well-being

Each year, the OECD makes and assessment of current well-being based on a multi-dimensional framework (OECD, 2020a). Table 15 presents a summary of the indexes which are themselves based on several indicators. Housing conditions index, for example, is based on the number of rooms per person and the housing expenditures. With 2,3 rooms per person, Australia is the 4th country with the largest dwellings in the world, behind Canada (2,6), United States (2,4) and New Zealand (2,4). Australia scores above average in most dimensions except work-life balance (time devoted to leisure and personal care as well as hours worked). Its results in this regard are closer to standards observed in Asia. The Nordic countries also perform better than the average in most indicators, except for housing conditions due to the high price of housing and its relatively smaller size than the average. Korea is generally below the average and ranks poorly in terms of social connections, work-life balance, and environment (water quality and air pollution), especially in Seoul's region. Korea also has the largest gender wage gap among OECD countries (OECD, 2016a). When asked to rate their general satisfaction with life on a scale from 0 to 10, people on average across the OECD gave it a 6.5. Except for Asian countries, selected countries all are at the top of the list.

Table 15: Well-being indexes, 2020

	Housing conditions	Community relations	Education	Environment	Health	Life Satisfaction	Work-Life balance
Korea	7,6	0,0	7,6	2,4	4,7	4,0	4,1
Japan	6,0	5,7	7,8	6,5	5,3	4,1	4,6
Austria	6,2	6,9	6,6	6,6	7,9	8,3	6,8
Germany	6,8	6,2	7,6	7,0	7,4	7,8	8,4
Netherlands	7,3	6,5	7,4	7,2	8,4	9,3	9,5
Finland	6,2	8,6	8,9	8,9	7,9	10,0	8,0
Denmark	6,2	8,8	7,9	8,3	7,9	9,7	9,0
Sweden	6,9	6,7	7,7	9,1	8,5	8,9	8,4
Australia	7,9	8,4	8,6	8,9	9,4	8,8	5,6
Canada	7,8	7,6	7,9	8,3	9,6	9,1	7,3

Source: OCDE (2020). As Singapore is not a member of the OECD, data are not available.

2.2.6 Governance structure

Cities are the main actors of change for sustainable mobility and green growth. However, not all cities have the same powers to achieve these objectives. It is also commonly said that unfolding the MaaS concept calls for the development of new governance structures (Audouin and Finger, 2019). This section gives insights about the governance structures that generate positives externalities in relation with shared mobility (EU, 2012; Musgrave and Musgrave, 1984; OECD, 2017, 2019b, 2020b).

Type of states

The level of autonomy of a public entity can be measured by three main criteria:

- **Legislative**: the ability to set up laws and regulations;
- **Taxing**: the right to introduce or abolish a tax, to set the tax rate, to define the tax base or to grant tax allowance/reliefs to certain households and firms;
- **Spending**: how services are organized, how funds are allocated and how service delivery is measured and monitored.

The separation of legislative, taxing and spending powers between each unit of government (national, regional, and local) varies from one country to another according to geographic, cultural, and linguistic disparities as well as past wars. As presented in Table 16, there are two main types of states. Unitary states have two levels of governance, while federal states have three levels. Regional disparities tend to be more important in federal states, where most powers are concentrated in the hands of the state governments. It is therefore more difficult to draw a national portrait of practices in those countries. In Canada, for example, each province has its own regulatory and financing system for the transportation sector. In Germany, each länder has its own constitution. Moreover, exceptions exist within countries. Berlin is one of the three city-states (*stadtstaaten*) in Germany, which means it is a city that benefits from the powers of a Länd. The review of practices in Berlin is therefore not representative of Germany as a whole, even if there is a lot of cities of the same size and economic importance within the country. Most selected cities have a special status within their own country. Table 17 presents the governance structure of the selected case studies.

Table 16: type of states

Federal countries	Unitary countries
Canada, Australia, Austria, and Germany	Other selected countries
Powers are shared between three levels of governance: • Federal government • State governments (provinces, states, länder) • Local administrations (regions, municipalities) The self-governing status cannot be altered by a unilateral decision of the federal government. Powers and responsibilities are assigned either by the constitution or by judicial interpretation. In general, federal governments have exclusive and listed responsibilities such as foreign policy, defence, money and criminal justice systems while federated states have extensive competencies (e.g. heath, education). Local governments are "creations" of the federated states and fall directly under their jurisdiction. There are often perceived more as a local administration than a government. Their responsibilities and financing means are defined by states and can thus differ from one state to another within a country. Municipalities cannot have independent relations with the federal government. Any investment project requires state's approval.	There are two levels of governance: • Central government • Subnational governments (regions, counties, municipalities) The unitary states are "one and indivisible". Subnational units can be created and abolished and their powers may be broadened and narrowed by the central government. Unitary states can thus be more or less decentralized depending on the extent of subnational powers. Local governments can have extensive competencies, such as health, social welfare, and education. In such case, the role of the central government is essentially to set national guidelines and manage international relations. some unitary countries recognize autonomous regions and cities, which have more powers than other local governments because of geographical, historical, cultural, or linguistic reasons.

Sources: (OECD, 2016b). (OECD, 2016c) (OECD, 2019b)

Table 17: Government structure in selected case studies

	Supranational	Central / Federal government(s)	State governments	Local governments or administrations
Finland	European Parliament (EP), European commission (EC), Council of European Union (CEU) and European Council	*Eduskunta*		311 *kunta*
Sweden		*Riksdag*		290 k*ommuner* 21 *landsting*
Denmark		*Folketing*		98 k*ommuner* *5 Regioner*
Netherlands		*Tweede Kamer* and *Eerste Kamer*		415 gemeenten 12 *provincies*
Germany		*Bundesrat and Bundestag*	*16 länder (*including Berlin*)*	11,054 g*emeiden, 3*
Austria		*Nationalarat and Bundesrat*	*9 Länder* (including Vienna)	2357 Gemeiden, 95 Bezirke (districts) and 15 Statutarstädte
Australia		House of Representatives and Senate	6 states and 2 territories	562 municipalities
Japan		House of Councillors and House of Representatives		1741 *sh*i *or m*achi 47 prefectures (including the Metropolitan government of Tokyo)
Korea		National Assembly of the Republic of Korea		229 cities, counties or districts 17 regions (including the Metropolitan government of Seoul)
Singapore		Legislative Assembly of Singapore		
Canada		House of Representatives and Senate	10 provinces 3 territories	More than 2,000 municipalities and administrative regions

Sources: adapted from OECD (2019b)

The European Union

The European Union (EU) is a new form of supranational government which presents certain similarities with federal countries. EU has the legislative, executive, and judicial bodies necessary for the administration of the powers which have been delegated to the Union by Member States. These powers are restricted to preserve the sovereignty of the Member States. To be approved, a law requires the majority. Taxation provision however requires unanimity. Therefore, there are emission standards, but no gas tax at the European level. Laws voted by majority, can bring significant and mandatory changes in Member States' policies. Even if they did not vote in favor, Members States are liable to the EU and may be subject to sanctions. Section 4.2 presents additional information on the operating mechanisms of the EU.

During a seminar at Oxford University in 2015, Mark Major, former director of the sustainable urban mobility committee of the European Commission (EC), summarized the powers and the challenges of EU regarding urban transport. Challenges that could be seen as similar to those faced by federal states. Urban transport is a local matter that must be solved by locally elected mayors to reflect local priorities and needs. However, air pollution and GHG emissions impacts do not stop at national borders which advocates to raise the issue at the highest level of government. Although there are local advisory committees, the EC cannot address cities directly. Directives are issued to Member States which are legally accountable to the European Union. In 2015, 27 on 28 Member States cannot comply to the EU's air quality standards largely because of vehicle emissions in urban areas. Mechanisms where national obligations are passed down to the local level are both complex and political. It is complex in the sense that the powers at the disposal of cities to achieve the objectives are determined by the Member State. It is political in the sense that cities sometimes find themselves at odds with the national orientation of their country regarding the solutions to be implemented to achieve the European objectives.

Decentralization

Decentralization refers to the assignment of powers to lower public entities. In the federations, this freedom returns mainly to the states, while in the unitary states they are in the hands of the regions (e.g. Sweden) or the municipalities (e.g. Finland). In Nordic countries, especially Finland, the local self-government principle is even enshrined in the constitution, which gives an additional protection to local powers against a change in political orientation at the upper levels of government.

Based on the definitions given in the fiscal federalism handbook for policy-maker by the OECD (OECD, 2019b), there is also deconcentration in Sweden and Finland, which means the central government is composed by several regional offices with a certain degree of autonomy in their decision-making processes. In other words, there is a geographic transfer of power from the central government to units based in regions. However, they are still hierarchical components of the central government. They do not have their own political leadership and cannot raise revenues, incur liabilities, or engage in financial transactions. They may provide national public services at the territorial level and play a significant role in implementing national policies at the regional and local levels, ensuring that they are in line with subnational government policies. They may also play a

co-ordination role between the different stakeholders, acting as a “pivot”, and "advisor" or "mediator" able to reconcile different perspectives.

Consistence between legislative taxing and spending powers

The three freedoms may not be consistent with each other. A city may have the capacity to legislate or to spend in an area under its responsibility, but not have the financial means to do so. Subsidies from higher levels of government (also called fiscal transfers), especially if tied to conditions, can be a form of indirect control from upper level of governments on local spending. For example, public transport is usually under the responsibility of municipalities. The cost of developing a mass transit system, however, usually exceeds the ability to pay of municipalities and requires financial assistance from the upper levels of government. This assistance may be conditional on performance targets or cost-benefit analysis schemes that are not aligned with local needs.

Inconsistence can also occur if a public entity has only partial control over an area with substitutable services. If the public transport responsibility is delegated to municipalities while upper levels of government maintain control on major road networks (MRN), such as highways, municipalities will have limited capacity to encourage modal shift to public and active transport. Controlling road capacity and road investment as well as road financial instruments such as tolls, mileage tax or vehicle's registration taxes helps align all incentives in the same direction. Another form of inconsistence takes place when investments by one level of government hurt investments by the other, either by a lack of coordination or a misalignment of the political orientations.

We observe three models of governance linking road and public transport.

- In the **first model**, the upper level retains road responsibility, but adopts local laws and instruments. In Sweden, the central government adopted a law allowing the implementation of congestion charging in Stockholm and Goteborg (Sveriges Riksdag, 2020). The power to collect revenues remains however in the hands of the central government. The disadvantage of such a system is that a municipality cannot modify the collection methods without the consent of the central government. Its advantage is that it makes it possible to consistently apply similar mechanisms in several cities. In Quebec, an example of such measure is the *Contribution des automobilistes au transport en commun*, a surcharge on car registration tax in regions with public transport services.
- The **second governance model** is to preserve all transport responsibilities in the hands of the upper levels. In Australia, Transport for New South Wales (TfNSW), an equivalent of the Canadian provincial ministries of transportation, is responsible for all modes of transport (transit, roads, taxis, freight). The agency was created in November 2011 and absorbed the Roads & Maritimes Services (RMS) in December 2019. Positive impacts of this integration remain to be demonstrated. The 10 years blueprint aims to offer more door-to-door transportation options for people and goods. Technological improvements are put forward more than environmental benefits (https://future.transport.nsw.gov.au).
- The **last model**, rarer given the technical and financial support necessary to accomplish such a mission, consists in delegating all the responsibilities to the

lower level. Transport for London, under the Greater London Authority, has been entrusted with this mission (TfL, 2020).

The combination of road transport and public transport responsibilities can also facilitate accountability of the government towards the population and more clearly present the benefits of public spending and investments to users and non-users of the services as shown in this infographic produced by The Independent Pricing and Regulatory Tribunal (IPART) of New South Wales.

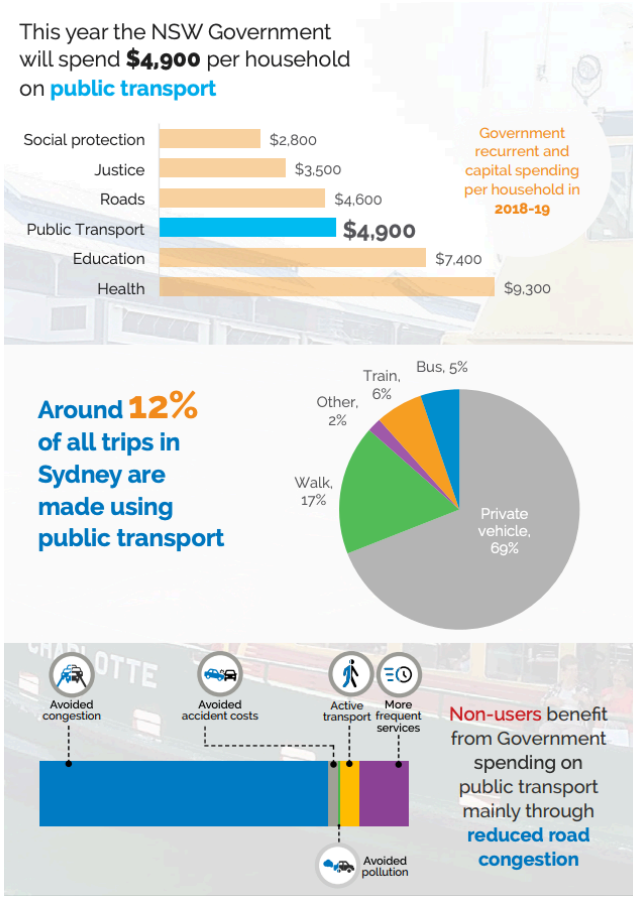


Figure 16: Example of a comprehensive public expenditures report, Australia, 2019

Source: IPART (2019)

Combination of responsibilities outside the transportation sector

In intergovernmental relations there is cooperation, but also competition and coordination problems (duplication of tasks, lack of intervention). This is true both between (vertical) and within (horizontal) levels of governance. Any organization generally seeks to fulfill its objectives while minimizing the impact on its own budget. The combination of certain responsibilities in the same hands can therefore have interesting spillover effects.

Municipalities in the Nordic countries, but also in the Netherlands and in Asia, have traditional local responsibilities such as transport and land-use planning, but they also have important financial responsibilities regarding health and social welfare. It is therefore not surprising that public and active transportation enjoy significant support, notably by

economic institutions. Investing in active transportation helps to reduce healthcare spending. In Denmark, the Ministry of Finance has estimated a socio-economic gain of 4.80 DKK (≈1 CAD) each time a new kilometer is traveled by bicycle in Copenhagen. This gain mainly corresponds to the reduction of traffic congestion and the improvement of health. If the trip replaces a similar car trip, the socio-economic gain amounts to 10.09 DKK (≈2 CAD) per km (City of Copenhagen, 2018). In Helsinki, a report on the benefits and costs of cycling completed in January 2013 shows that an annual investment of 20 million euros in cycling would produce sizable social benefits, especially by reducing health costs. The benefit-cost ratio is many times greater compared to normal road investments. The cost-benefit ratio is nearly 8, meaning that an investment of 1 EUR would produce benefits worth 8 EUR (City of Helsinki, 2013). In 2019, Helsinki recorded zero pedestrian and cyclist deaths and only three traffic deaths (one car driver and two motorcyclists) (Eltis, 2020a).

In Finland, the Ministry of Transport is also responsible for communications. The combination of these two fields of expertise, but also the presence of a regional government office in Helsinki, seems to have opened specific opportunities for a MaaS ecosystem. In Germany, the Federal Ministry of Transport is also responsible for the Digital Infrastructure. In Austria, the Federal ministry for transportation is also responsible of Innovation and technology.

In Denmark, the ministry of transport is also responsible for the housing sector. At the end of the 1980s, Copenhagen was facing major problems: weak economic growth, high unemployment, and municipal debt. Public consultations highlighted the need for public infrastructure investment. The construction of the metro was partially funded by real estate development by the public enterprise Ørestadsselskabet. Today the public real estate development company, By & Havn, pursues a similar mission in the Ørestad region. Revenues from its activities still support the public infrastructure of Copenhagen.

Table 18 shows the division of responsibilities in Canada. The powers required to develop an intelligent and sustainable transportation system are therefore distributed among several departments and levels of government, which requires a higher level of collaboration and coordination.

Table 18: Division of responsibilities in Canada

Federal government	Provinces	Municipalities
• Transport Canada (international and interprovincial transportation) • Environment Canada (international agreement, pollution in relation to international trade, e.g. vehicle emissions standards) • Sciences and Innovation Canada (Open Data) • Canadian Heritage (broadcasting) • Health Canada (safety concerns regarding product and services, patent) • Families, Children and Social Development Canada (Canadian Mortgage and Housing Corporation)	• Provincial ministries of transportation (intraprovincial transportation) • Provincial ministries of environment (sectoral pollution, e.g. road traffic) • Provincial ministries of health and social services (hospitals, medical service prevention, homecare) • Provincial ministries of municipal affairs	• Delegated financial powers and responsibilities in local transport (local roads, public transport, and active modes) • Land-use planning and regional development

Sources: (LOP, 2013, 2011)

2.3 Shared mobility services comparison

This section compares the attributes of the different shared mobility systems in the cities studied. Comparisons with Montreal and/or Toronto can be made to highlight similarities and differences with familiar systems. These two cities have not, however, been the subject of actual case studies.

2.3.1 Transit and microtransit systems

The information in this section comes from the official websites of transport agencies. The governance structure and organization of transport services varies considerably from one city to another. Table 19 is sorted by service level (as measured by VKM reported in UITP Mobility database for year 2012). As the metro system is generally considered to be the backbone of urban transport systems, the table also includes the date of opening, the last extension, and the number of stations in the metro network. It has been impossible to reconcile other performance indicators consistently. We can however conclude that the level of use of a public transportation network (PKM) is multifactorial.

Table 19: Transit services comparison, 2020

City	Fare authority	Metro	Light Rail/Tram	Bus	Commuter train	Ferry	Micro-transit	Metro opening	Last expansion	Metro stations / million inhabitants	VKM / cap (2012)	PKM /cap (2012)	Cars / 1000 inhab.
Sydney	TfNSW	RC	TfNSW/ SLR	StT	SyT/ TL	StT		2019	2019	3	50	1 155	500
Singapore	PTC	LTA/ SBS / SMRT1						1987	2020	22	84	2 659	116
Vienna	WL				ÖBB		AT	1976	2017	35	99	1 733	390
Tokyo	Toei	Toei	Toei / JR	Sev	JR			1927	2008	7	106	5 684	329
Helsinki	HSL							1982	2017	17	108	1 909	391
Berlin	VBB	BVG	BVG/ DB	Sev.	DB	BVG		1902	2009	34	130	1 968	339
Copenhagen	DOT	MS		Mo	DSB	Mo		2002	2020	19	143	2 246	360
Stockholm	SL					WB		1950	1994	43	144	2 482	389
Amsterdam	GVB				NS			1977	2018	14	NA	NA	371
Seoul	SM			Sev.	KO			1974	2019	14	NA	NA	271
Montreal	ARTM	STM		Sev.	Exo			1966	2007	15	50	1140	573
Toronto	TTC			TTC / ML	ML			1954	2017	11	NA	NA	NA

Sources: public transport organization's official websites and UITP (2015). Note: public (light blue), private (red), public-private partnership (dark blue). Sev. = several operators; Sweden : Storstockholms Lokaltrafik (SL), Waxholmsbolaget (WB); Helsinki : Helsingin seudun liikenne (HSL), Kutsuplus (Ku) ; Copenagen : Din Offentlige Transport (DOT), Metroselskabet (MS), Movia (Mo), Danske Statsbaner (DSB); Amsterdam : Gemeente Vervoerbedrijf (GVB). Nederlandse Spoorwegen (NS), Mokumflex (MF); Berlin: Verkehrsverbund Berlin-Brandenburg (VBB), Berliner Verkehrsbetriebe (BVG), S-Bahn Berlin (Deutsche Bahn, DB); Sydney: Transport for New South Wales (TfNSW), State Transit (StT), RailCorp (RC), SydneyTrains (SyT), TrainLink (TL), Sydney Light Rail, (SyLR) è Seoul: Seoul Metropolitan Rapid Transit Corporation (SMRT2); Singapore: Public Transport council (PTC), Land Transport Authority (LTA), Singapore's first mass rapid transit (SMRT1), Singapore Bus Services (SBS); Montreal: Autorité régionale de transport métropolitain (ARTM); Toronto : Toronto Transit Commission (TTC), Metrolinx (ML); Vienna: Österreichische Bundesbahnen (ÖBB), Wiener Linien (WL), Anruf-Sammel-Taxi. Seoul: Seoul Metro (SM), KORAIL (KO).

Transport governance

Helsinki, Stockholm, Vienna, and Amsterdam have the simplest systems where a single local public authority manages with one hand all services and produces a consolidated annual report. In Sydney, TfNSW organizes all the services, but delegates operations to public and private subsidiaries. Sydney Light rail is notably entrusted to Transdev.

In Copenhagen and Berlin, the cohesion between the services is maintained by a public association organization. In Berlin, the public association of operators (VBB) covers two administrative states (Berlin Land and Brandenburg Land).

In Asia, transport operators are incorporated as public companies. They rely on an independent profit-based system, fares must at least compensate for the running costs. The private sector has also a greater role especially for the provision of bus services. After the Asian systems, Amsterdam has one of the most profitable systems with a recovery rate (fare revenues / operating expenses) approaching 70%.

Interesting fact Seoul Metro reserves an annual budget for citizen participation. Citizens (businesses excluded) can propose projects that improve the pleasantness of metro journeys and the well-being of users. The ideas proposed must cost no more than one billion won ($ 1.2 million).

Fares system and structure

The fare system for most public transport systems is made up of concentric areas. Taking distance from the center typically results in a higher fare. Asian cities, but also Sydney and Amsterdam have a pure kilometric system.

In Amsterdam, the fare map looks like a patchwork of 30 km^2 zones (https://reisinfo.gvb.nl/nl/zones). The base rate for traveling within an area is 0.98 EUR. The passage from one zone to another, regardless of the direction, leads to a 0.170 EUR / km increase. It is however still possible to buy a monthly or annual subscription like other Europeans cities, the price of which varies according to the number of zones included. The fare system could therefore be described as hybrid.

In Sydney and Asian cities there is no monthly or annual passes. The fares are calculated based on the distance (tap on / tap off system), the time of the day (peak / off-peak/ Sunday) the method of payment (tickets bought on app are usually cheaper), the mode of transport (bus services tend to be more expensive) and individual characteristics (e.g. student). In Sydney, unlike Asian cities, there is a daily cap (16.10 AUD) and weekly cap (50 AUD).

Given the relatively low ridership and PT modal share in Sydney, it is not certain that the complexity of the kilometric system generates as many efficiency benefits as in Asian cities or Amsterdam where the network is saturated. However, careful thought guides pricing strategy in Sydney. The Independent Pricing and Regulatory Tribunal (IPART) of New South Wales conducts detailed pricing analyzes every five years. Sydney fare system has already undergone two major reforms, MyZones in 2011 and full transition to Opal fares in 2016. For the period 2020-2024, IPART recommends, among other things, to review the distance bands and adjust relative prices for shorter and longer distances (IPART, 2019).

Internet deployment over the past 30 years facilitates the performance of benchmarking studies. The practices of transport agencies around the world are increasingly similar. Several transport agencies have undertaken fare reforms in recent years. Three trends are observed in this regard:

- metropolitan fare integration;
- implementation of a distance-based system;
- differential fare according to the mode of transport (rail vs bus) or time of the day.

This is the case of Copenhagen. Before 2017, the greater region of Zealand used to have four different tariff systems. Today the transport systems are integrated, and the region is divided into 211 zones. The price depends on the number of zones crossed. Special rates are offered for the central region (zone 1 to 4).

The type of fare system, however, does not appear to have an impact on the affordability of the service. Table 20 shows the purchase price of various public transport tickets for an adult in the most central zone. For kilometric system, the rates correspond to a 10-kilometer trip in the central area during rush hour. Prices are in USD PPP (purchasing power parity.

Table 20: Transit fares comparison, USD PPP, 2020

USD PPP	Single	One day	Monthly pass or equivalent*	Annual pass	Ratio (monthly/single)
Seoul	1,59	NA	65	776	41
Vienna	3,13	7,57	67	477	21
Helsinki	3,25	9,3	69	741	21
Copenhagen	2,08	22,97	72	870	35
Tokyo	1,93	NA	74	796	38
Singapore	1,08	NA	91	1089	84
Stockholm	4,15	17,38	104	1096	25
Berlin	3,91	11,59	113	981	29
Amsterdam	4,06	10,15	127	1269	31
Sydney	2,45	8,15	136	1631	55
Montréal	2,91	8,32	72	863	25

Sources: official website of the transport agencies, OECD PPP conversion rates and authors' calculation. Note: the fares correspond to an adult rate in the most central zone. For kilometric system, the rates correspond to a 10-kilometer trip in the central area during rush hour.

Microtransit

Most cities offer on-demand transportation for people with special needs, including people with disabilities or hospital transportation in northern regions. This section focuses on microtransit services offered to the general public. Almost all projects identified in this regard are pilot projects organized by a public transport authority with or without a partnership with the private sector.

Helsinki

HSL tested the world's first fully automated, real-time demand-responsive public transport service (HSL, 2016). The service called Kutsuplus consisted of 15 minibuses and a route optimization system based on trip orders from customers.

The field testing of the Kutsuplus service with real passengers started on schedule on October 1st, 2012, with three vehicles operating 8 hours a day on weekdays. During the next few weeks, the fleet and operating hours were expanded. The authorities hoped to be able to extend the service to the whole city within a few months. In the testing phase, aggressive pricing of €1.5 + €0.15/km was used. The price of the service has then been increased several times and incentive rates have been put in place to flatten the morning and evening rush-hour peaks and improve the availability of the service. At the end of 2015, 100 000 trips were ordered or 1.8 trip per vehicle-hour. Despite the popularity of the service, the small-scale operation required, as expected, substantial subsidies. The municipalities, who were facing financial difficulties at that time, chose not to continue the project.

The majority of Kutsuplus customers were male aged between 30-44 years old, whereas most traditional public transport service users in the Helsinki metropolitan area are female. According to a study conducted in October 2013 (n=442), 56% of registered users had one or more private cars in their household. According to a study done in the spring-fall of 2014 (n=244), 100% of the users had a driving license. Kutsuplus was found useful (n=355) for personal matters and shopping (79%), business trips (65%), trips to hobbies (50%), trips to school/work (48%), and various other kinds of trips (12%).

In 2019, new on-demand pilots were developed in the Helsinki region by Kyyti Group and ViaVan in collaboration with HSL. Some directed at the general public for providing first/last mile connections to metro stations, some dedicated to providing school children with after-school transportation to hobbies (instead of parents driving them around later in the evening).

Amsterdam

Since 2018, the city of Amsterdam has offered microtransit services through a pilot project, Mokumflex, in the Landelijk Noord district which replaced two regular bus line. The service is available from 6am to midnight. Trips must be booked at least one hour in advance and up to 7 days. The vehicle can arrive at the chosen stop up to 15 minutes before or 15 minutes after the chosen time. The user is informed of the vehicle arrival via the application. The service aims to increase the transport options for target customers, such as the disabled people, students, or people traveling in rural areas. The service was initially free. Since august 2019, the cost of the service is € 2.50 per person, payable by automated payment. The transport service is provided by RMC, a company specializing in mobility.

Sydney

Since 2018, TfNSW has carried out several pilot projects for On-Demand Public Transport services throughout its territory, including 7 in the Sydney regions. Vehicles are cars, vans, buses or even ferries that offer a link to a public transit station or certain drop off location (eg shopping centers, hospitals). It is possible to book online or by telephone up to 48 hours in advance. The services are offered by BRIDJ. In 2019, 24,000 people used the service. Few details are available on the results of the pilot projects. Many user reviews on the AppStore, however, point to the unreliability of the services.

Vienna

The city of Vienna has been offering microtransit services in the form of collective taxis for the past fifteen years. About 120,000 people use the Anruf-sammel-taxi (ASTAX) service, which means call-a-ride, each year. Shared taxis operate on 17 defined routes and travel from residential areas on the outskirts of the city to central locations. The level of service varies from line to line. They sometimes replace existing bus lines at night. The travel request must be placed at least 15 minutes before the start of the trip. The taxi operates at the current rate of Wiener Linien. Holders of an annual and monthly subscription pay nothing more. For people who do not hold a transit pass, the ticket must be purchased in advance (https://blog.wienerlinien.at/astax/).

Private initiatives

In Berlin, a start-up called Allygator Shuttle offers on-demand transportation services independently at a cost of 5 cents per kilometer. The service is temporarily stopped.

In Vienna Berlin, ViaVan, a private company founded in 2017 as a joint venture between Mercedes-Benz Vans and US vehicle-sharing service Via, offers a service inbetween ridepooling and on-demand transit as there is no fixed stations, but users sometimes have to walk hundred meters to get their transport.

In Singapore, ShareTransport offers buspooling services. Consumer suggest a route and when there is enough demand, they start offering the service. The company invite customer to tell their friends if they are dissatisfied with their daily commute.

2.3.2 Bikesharing systems

Bikesharing is the first form of public vehicle sharing system. The idea comes from a Dutch activist movement who claimed a decrease in the space allocated to cars in the city center of Amsterdam in the 1960s. About fifty bikes were painted white and left in public space so that people could use them freely. Most bikes were unfortunately stolen, damaged or seized by the police. Although the experience lasted less than a month, the idea has inspired hundreds of initiatives around the world. Most “free systems” suffered the same fate. For example, the Austin’s Yellow bike project, born in 1997, converted its activities a few years later as a community bicycle shop and repair.

The first official and large-scale bikesharing system has been launched in Copenhagen in 1996 (*Bycykler København*). Users had to pay a refundable deposit for unlimited use inside downtown area. The scheme was funded by the municipality of Copenhagen and commercial sponsors which could in return put advertisements on the bike frame. Since the deposit amounts was much lower than the value of the bikes, the system was also victim of theft or neglect. In 2012, *Danske Statsbaner* (DSB) organized a call for tenders to replace the existing system. Bycyklen, a Danish start-up, won the contract as a non-profit operating company. According to Bycyklen’s website, the bikes are equipped with a smart tablet to allow three specific functions: allow advance reservations, offer users real-time trip planning and allow them to drop off a city bike when the docks are full in order to prevent users from missing their connection as offered in Germany by the Deutsche Bahn (national railway company) since 1998. Call-a-Bike is offered in 40 German cities, making it one of the largest bikesharing systems in the world. The cable lock allows bikes to be

locked on dedicated biking racks or in free-floating mode directly on the wheel following the city regulation. Even in cities with a rack-based system, the Deustche Bahn allows users to end their journey anywhere in exchange of an additional fee of 1EUR. In Copenhagen, Bycyklen is a hybrid system with docking stations and an integrated locking system on the wheel. That feature allows users to pause their journey anywhere, in a park or in a local business for example, without returning the bike, which would make it available for other users. Users continue to pay by the minute when they use this function. In 2019, the smart tablets of more than 900 Bycyklen's bikes were subjected to targeted vandalism, an unprecedented situation (TV2, 2019).

The literature generally agrees that there are four major technological generations of bicycle sharing systems, as summarized in Table 21. Some authors however consider the development of hybrid systems to be separate generations. For example, station-based systems with physical docks accessible by mobile app are sometimes called "generation 3+" or "generation 4". Free-floating are sometimes called "generation 5" and geo-station systems with virtual dock could even be considered as the sixth generation. In the latter case, bikes can only be parked in designated areas. Geostations (also called geofencing or hub-centric systems) help to reduce careless behaviors users, but dockless systems remain more prone to vandalism.

In addition to geostation, some compagnies have also introduced bonus-malus pricing strategies to reduce their operating costs. Economic incentives can help to reduce acts of neglect compromising the integrity of bikes but can also encourage a natural rebalancing of the bikes. Penalties can be applied when bikes are improperly parked, or rewards can be offered for bikes returned to the original station.

According to "The Bike-sharing World Map 2020" website, more than 2150 cities around the world had at least one bikesharing system program. Most cities have only a public system, some also have a private free-floating system. Some cities, like Berlin (Germany) or Beijing (China) have up to 8 different systems on their territory. Spain, the United Kingdom, and the United States are the countries where the most systems have stopped their operations. China has the most developed bikesharing market in the world. In the end of 2017, 77 compagnies were renting 23 millions bikes to 400 millions users in 200 cities (Bieliński and Ważna, 2018).

According to the 2019 Copenhagenize index (https://copenhagenizeindex.eu), the three friendliest cities in the world for cyclists are Copenhagen (DNK), Amsterdam (NDL) and Utrecht (NDL). The other cities that stand out in the ranking from our case studies perspective, based on their infrastructure, culture and ambition for cycling, are: Oslo (7, rising star), Helsinki (10), Berlin (15), Tokyo (16), Vancouver (18) and Montreal (19).

Table 21: Generations of bikesharing systems

Technological generations	Free bikes (1965)	Coin-deposit system (1995)	Smartcard system (1996/2005)	Smartphone app (2014)
Components	Distinct bikes Free-floating Free of charge Unlimited time	Distinct bikes Station-based Coin access Unlimited time	Distinct bikes Station-based Smartcard access Limited + extra charge Subscription Mobile device access GPS tracking Real-time information	Distinct bikes Free-floating (smartlock) Mobile device access Distance-based fee Pay-as-you-Go Bonus-malus GPS tracking Real time information Geostation
Financing scheme	Non-profit Government University	Non-profit Government	Fees Cities / PT agencies Government Advertising companies	Fees Investors Advertising compagnies For profit
Advantages	Greater destination proximity and time flexibility	Greater time flexibility	• Greater origin certainty with defined station locations • Affordability for regular users • Ordered urban space	• Greater destination flexibility / proximity • Low initial investment cost
Disadvantages	Theft Vandalism Negligence	Theft Vandalism Negligence	• Lower destination flexibility /proximity • Docking availability uncertainty • More travel planning required • High initial investment costs	• Weaker origin certainty • Vandalism • Negligence (e.g. inappropriate parking) • Higher operational cost (redistribution and bikes replacement) • Not affordable for regular users
Example	Witte Fietsenplan (Amsterdam, 1965) Yellow Bikes (Austin, 1997)	Bycykler (Copenhagen, 1996) Viennabikes (2001)	Vélos à la Cartes (Rennes, 1998) Vélo'v (Lyon, 2007) Bixi (Montreal, 2009)	Ofo (2014) Mobike (2015) Jump (2010, Uber 2018)

Source: Adapted from Shaheen and al. (2012), (Bieliński and Ważna, 2018; Midgley, 2011)

Among our cases studies, several cities, including Stockholm, Sydney, Singapore, and Amsterdam do not have an official bikesharing system owned or financially supported by a public partner. As presented in Table 22, despite their public or quasi-public nature, very little information is available on these systems which also present a wide variety of business models:

- For several years, Stockholm had a public-private system called CityBikes (www.citybikes.se/). The agreement was however not renewed this year while the city is considering other options. The city's cycling goals are however important. By 2030, city except that 15% of all rush hour trips will be made by bicycle. The city is even promoting winter bikes. Between 2012 and 2022, Stockholm invested 2 billion SEK (300 M$) in the extension of the cycling network, the addition of one way and the addition of 3000 parking spaces each year (Stockholms stad, 2020a). Since 2019, right turn on a red light is authorized for cyclists in Stockholm. The city gave its green light after the traffic office evaluated the results of this measure in the Netherlands, Germany, and Denmark. As in the Netherlands, priority green lights in all directions are also implemented in narrow intersections (Stockholms stad, 2020b).

- In Sydney, the city does not manage bikesharing. Private companies operate bike share schemes. The same goes for Amsterdam. Unlike Sydney, the absence of a municipal system is probably explained by the large use of private bicycles.
- In Singapore, SG Bike is a local start-up who also does not seem to receive financial support from the city. Since the commercial bankruptcy of OBike, another local start-up, and the merger with Mobike (Chinese start-up), SG Bike is the only bikesharing system available in Singapore.
- In Copenhagen, Bycyklen users must now choose between the pay-as-you-go format (1 DKK per minute, (0.20 CAD) or an hour bank valid for up to one year. The largest package offers 40 hours at cost from 0.38 DKK / minutes (0.08 CAD). Users can park the bike without releasing it, so they can enter a store to make a purchase and then pick it up if they continue to pay. To complete a journey outside an area of the urban bicycle station in Copenhagen, there is a fee of 200 DKK (40 CAD). If the journey is completed in another city, the fee is 1000 DKK (200 CAD).
- The City of Berlin does not have an official system, however the two main operators in the region have their bicycle network. The Deutsch Banh has its "Call a Bike" system which it makes available in several cities in Germany to complete the first and the last kilometer from its train stations and travel around the city. VBB has forged a partnership with Nextbike, a private company from Leipzig (Germany). Both systems allow to return bikes to a fixed station at no cost or to leave the bike anywhere in the city for a fee of EUR 1 or less.
- The first system in Vienna, Viennabike (2001) suffered the same fate as Bycykler København from which it was inspired. The City of Vienna proceeded by a called for tenders to replace the system, which was won by the advertising company Gewista who has been managing the system since 2003. Since 2007, the service has been offered all year round without winter breaks. However, it is small system. Users must register to prevent theft, but the use of bicycles remains free for the first hour. Subsequent hours are priced at a progressive rate. It is not possible to take a season pass.
- In Tokyo, Docomo community service also has no competition. Despite the size of the market, the city seems to want to avoid making the same mistakes as China, whose public space has suffered from bikesharing oversupply.

Table 22: Bikesharing systems with public partners, May 2020

City	Services description	Owner type	System type	Bikes (n)	Stations (n)	Bike Trips (M)	Biket km (M)	One-Way (US PPP)	Day (US PPP)	Season (US PPP)
Stockholm	None for the moment									
Helsinki	Kaupunkipyörät (2016)		SB	3450	345	3,2	6,3	NA	9	51,50
Copenhagen	Bycyklen (2012)		SB	NA	NA	NA	NA	TB	TB	TB
Berlin	LIDL -Call a Bike (DB) (2000)		H	NA	NA	NA	NA	TB	12	NA
	Nextbike (VBB) (2004)		H	NA	NA	NA	NA	1,30	4	NA
Amsterdam	None for the moment									
Vienna	CityBike Wien (2003)		SB	1200	121	1	3,5	TB	NA	NA
Sydney	None for the moment									
Tokyo	Docomo Bikeshare (2014)		SB	NA	NA	NA	NA	1	14	NA
Seoul	Ddareungi (Seoul Bike) (2015)		SB	3000	300	NA	NA			
Singapore	SG Bikes (2017)		FF	NA	NA	NA	NA	0,70*	TB	NA
Montreal	Bixi (2009)		SB	7430	611	5,8	10	2,50	4,40	80,70

Source: official websites. Legend: Owner: public (P), private (FP) or non-profit (NP), System: station-based (SB), free-floating (FF) or géo-station (GS), time-based fare system (TB). Note:

Several multinationals, especially Chinese, American, Dutch, and German, have emerged in recent years in the bikesharing market. Two giants and pioneers, Ofo and Mobike, however have gone bankrupt in the past year. It is a market in which it is relatively easy to enter with the gradual decrease in the cost of developing a platform and purchasing bikes. This may seem like an easy business opportunity for some well-capitalized companies like Uber or Alibaba. This may also be the reason for the low profitability and bankruptcies. In some markets, companies have used two tactics. The first is a price war aimed at breaking competition. The second is to drown the streets with as many bikes as possible to have the greatest market visibility. A cash-burning operational costs strategy that has fueled criticism and harms prospects for future development. According to Forbes, Ofo has gone from school project to billion-dollar start-up to the verge of bankruptcy in less than four years. The result of a chaotic and irrational competition between greedy investors (Forbes, 2018).

Berlin Amsterdam and Vienna are the three cities where there is the most competition between bikesharing companies. Most of the companies presented in Table 23 can however be found in at least one city in each of the countries selected. For example, Donkey Republic can be found in 7 Swedish cities and 9 Finnish cities. If a competitor is already present in the capital region, companies seem to turn to smallest city within the same country. We also observe that these companies have their own regional influence network except for American companies, the subsidiaries of Uber (Jump and Lime) which can be found all over the world. These companies display even less information publicly including even on the tariffs which vary from city to city.

Table 23: Commercial bikesharing companies, May 2020

City	OBike	Ofo	Mobike	Nextbike	Donkey Republic	Hello Bike	Urbee (e-bike)	FickBike	Dropbike	Jump (e-bike)	Limebike (scotter)	Birds (Scooter)	TIER (scotter)
Origin	SG	CNA	CNA	GER	DNK	NDL	NDL	NDL	CAN	USA	USA	USA	GER
Type	FF	FF	FF	H	H	FF	FF	FF	FF	FF	FF	FF	FF
Stockholm													
Helsinki													
Copenhagen													
Berlin													
Amsterdam													
Vienna													
Sydney													
Tokyo													
Seoul													
Singapore													
Montreal													
Toronto													

Source: official compagnies' website. Legend: orange = for profit, gray = no longer in service

2.3.3 Carsharing

The first carsharing organization was founded in Bassel (Switzerland) in 1987. Table 24 presents the carsharing services that have been found in the selected cities. Companies with similar characteristics have been grouped in the same columns and are separated by the symbol "/". Most cities have at least two systems, one station-based (rountrip) and one free-floating (one-way). Rates are available by the minute, hour, and day. Station-based systems generally require the selection of a subscription plan with fixed annual fees. Most providers are private companies. No company offers both station-based and free-floating systems like it is the case in Montreal with Communauto. Unlike bikesharing systems, these are mainly local companies. Car rental companies have not been thoroughly identified. However, this sector has more multinationals (Hertz, Europtcar and Sixt). Special features to mention concerning carsharing systems:

- Green Mobility offer the possibility to prebook a car from 79 DKK. The car could also be delivered close to an address or directly at the Doorstep. DriveNow (BMW) offers the same service for free.
- In Copenhagen, Letsgo carsharing is a non-profit organization since 2004.
- Also in Copenhagen GoMore offers carpooling services as well as P2P car rental. Bloxcar also offers P2P car rental services in Finland and Drive lah in Singapore.
- In Austria, the national railway company (ÖBB) offers a carsharing services accessible with rail card.
- In France, Orange telecommunications offers a carsharing system to its employees.
- Three carsharing companies can be found in Tokyo (Orix, Times and Careco). They are all station-based and offer a wider selection of cars compare to traditional carsharing companies.
- The three carsharing companies in Singapore are part of the Car-sharing Association Singapore (CSAS) whose objectives are to promote carsharing, forge

international partnerships but also provide a central carsharing database and depository.

Table 24: Carsharing companies, May 2020

City	DriveNow (Car2Go, BMW)	Green Mobility	Letsgo	ÖBB Rail and drive	Goget	Fetch	Greenwheels	Aimo / Sunfleet (Volvo)	CityCarClub	Orix / Times / Careco	GreenCar / SoCar	BlueSg	CarClub / WhizzCar
Origin	GER	DNK	DNK	AUT	AUS	NDL	NDL	SWE	FIN	JAP	KOR	FRA	SG
Type	FF	FF	SB	SB	SB	FF	SB	FF	SB	SB	FF	FF	SB
Stockholm													
Helsinki													
Copenhagen													
Berlin													
Amsterdam													
Vienna													
Sydney													
Tokyo													
Seoul													
Singapore													

Source: official compagnies' website. Legend: orange = for profit, green = nonprofit, blue = public, gray = no longer in service, M = minute rate, H = hourly rate, D = day rate, B = bank of hours.

2.3.4 Carpooling

We can distinguish three types of carpooling in practice:

- Kiss and ride carpooling: typically carried out between two members of the same household to go to the same employment area or to a public transport station.
- Commuting carpooling: allowing workers to share the cost of travel. Services are typically organized by employers (carpooling between colleagues) or by governments. The underlying objective is generally to reduce the demand for parking (at the workplace or in city centers) as well as congestion levels.
- Long distance carpooling allowing individuals to travel between cities, regions or countries for all kinds of purposes. These carpooling services can be organized through non-profit groups, sometimes present on social networks, or mobility providers who develop and own the platform that connects individuals (P2P business model.

The literature search was limited to public programs and commercial enterprises offering mobility services. The company BlablaCar (created in France in 2006) sits at the top of the mobility companies for long-distance carpooling in Central Europe (Germany, the Netherlands). It acquired its main competitor, Carpooling.com (Germany), in 2015. Northern countries have their own mobility provider, such as Samåkning.se (Sweden) and GoMore (Copenhagen), Ryde (Singapore). No significant carpooling services were found in Japan and Korea. Australia is one of the countries where we found the largest number of carpooling initiatives, including Hitch, Hop and Kapuddle. In Finland, Kyydit, as Fahrgemeinschaft in Germany, offers a non-profit service. Since 2012, two start-ups, DriiveMe and Hiflow have offered combined (or not) vehicle rental and carpooling services

at very low prices (up to EUR 1). Vehicles are owned by car dealerships or vehicle rental companies that need to balance their fleet from one region to another. In 2005, Hertz Freerider was a predecessor service. The rental company covered the travel costs of individuals returning the vehicles to the targeted service centers.

2.3.5 Ridesharing and ridepooling

Most cities have their own local traditional taxi service companies but only P2P ridehailing and ridepooling services have been identified. This sector is occupied exclusively by private companies and multinationals as presented in Table 25. Helsinki is the only city where there is no ridehailing company. In Finland, the Act on Transport Services that came into effect in 2018 changed the landscape for taxis and ridehailing services. For example, it removed the cap on taxi permits, price ceilings as well as location and time-based requirements on taxi availability. Since then, the number of taxis has increased by 25 % in Finland between 2017 and 2018, especially in Helsinki region (TRAFICOM, 2019). The aim of the legislative reform was to increase freedom of choice in the transport market. Part of this act ensures that regardless of the mode of transport, a mobility provider shall provide up-to-date data on its services from an open interface. The data should also be provided in a standard, easy to edit and in a computer readable format. The information should include, at minimum, stops, timetables, prices, availability, accessibility as well as an access to sales interface (UITP, 2019). In Australia, the star-up Hop offer ridehailing services, but driver do not need to own their own car as Hertz rental company can supply vehicle for 6 AUD per hour. Also, in Australia, Shebah offers ridesharing services for woman only and father with their children.

Table 25: Ridehailing and ridepooling companies, May 2020

City	Uber (2009)	Lyft (2012)	Didi (2012)	Ola Cab (2010)	Bolt (2013)	ViaVan (Mercedes-Benz et Via) (2017)	Grab / GoJek (2012)
Origin	USA	USA	CNA	IND	EST	US/GE	SG
Type	RH	RH	RH	RH	RH	RH/RP	RH
Stockholm	■				■		
Helsinki							
Copenhagen	■						
Berlin	■					■	
Amsterdam	■						
Vienna	■					■	
Sydney	■		■	■			
Tokyo	■		■				
Seoul	■						
Singapore							■
Montreal	■						
Toronto	■	■					

Source: official compagnies' website. Legend: ridehailing (RH), ridepooling (RP)

2.3.6 Mobile app, mobility packages and open data policy

Table 26 shows the different mobility platforms in the selected cities. These are official platforms endorsed by local governments or applications that have been developed by the private sector in these cities (at least at first). Only the platforms which group together several operators and several modes were analyzed. Applications developed in other cities, for example Moovit (Israel) or Citymapper (London), which can also be used in selected cities have not been covered.

Table 26: Comparison of official mobility app, May 2020

City	Services description	Owner	Trip planning	Real time (R)	Price info (I)	Service Info	Booking (B)	Payment (P)	Package (U)	Transit / microtransit	Bikes	Scooter / mopped	Carsharing	Taxis/ ridehail/pool	Carpooling	Car rental	Parking / Echarging
Stockholm	UbiGo									L			1	1		1	
Helsinki	Reitiopas									L							
	Whim									L	1	1		3		3	
Copenhagen	Rejseplanen									N	2		2		1	P2P	
Berlin	BVG									L	1						
	DB									N	1						
Amsterdam	Amaze (2020)																
Vienna	WienMobil									L	3	3	2	2		3	3
Sydney	TripGo									L			2				2
Tokyo																	
Seoul																	
Singapore	Zipster									L	1	1	2	2		1	
Toronto	Triplinx									L	1		1				
Montreal	Chrono									L							
	Transit									L	1		1	1			

Source: official app. Legend: orange = for profit, blue = public, L = local, N = national, the number corresponds to the number of different compagnies included in the app.

The next subsections deal in more detail with the applications considered in the foreground of the MaaS concept (Whim, Ubigo and WienMobil). A few notes before that concerning certain features that stand out:

- Two app, Resjeplanen (Denmark) and Deutsch Bahn (Germany), are available in the whole country, giving information on the local and interurban (only national rail company) transportation services.
- In Helsinki, HSL app provides detailed information on the state of services, including streets, stairs and elevators closed for construction. The application specifies the end date of the works and the alternative stops.
- In Berlin applications offer a wide variety of contactless payment methods (debit, credit, Paypal and prepaid cards).
- In Denmark, Rejseplanen's offer seamless transportation alternatives all over the country, both in metropolitan and rural areas. The app also includes carpooling and P2P car rental services between individuals.
- In Vienna, WienMobil also gives information on car and bike parking availability and costs as well as e-charging stations.

- Amsterdam, Tokyo, and Seoul do not yet have their own multimodal application. In Amsterdam, the GVB app only contains information on the public transport network. Rumors were circulating, however, about the launch of an application developed by a consortium of four developers (Over Morgen, Amber, Radiuz and Transdev) in May 2020.
- Many applications are a public-private partnership. In Singapore, Zipster has been developed by mobilityX is an SMRT and Toyota Tsusho funded start-up. In Vienna, WienMobil has been developed by the national rail company (ÖBB) and the private utility company (Wiener Stadtwerke AG). In Stockholm, SL and various private transport operators such as Cabonline, Hertz and MoveAbout founded the start-up Fluidtime.

Helsinki

The EU presented its ITS action plan in 2008 and its directive to the Member States in 2010. Since 2009, the Finnish Ministry of Transport and Communications has tried to pave the way for the development of MaaS by developing public–private interactions at strategic levels. In 2011, the government published the Transport Revolution Report which was an important governmental collaborative work launched jointly by The Finnish Innovation Fund's, the Ministry of Transport and Communications, the Ministry of Employment and the Economy, the Ministry of Finance, the Ministry of the Environment, two national Transport Agencies, and two strategic centres for science, technology and innovation. The report presents the new perspectives, structures or practices identified all over the world under the four main headings: New governance and organisation structures; Increased efficiency; End-user based design; and New operational procedures to boost transport innovations. The report is relatively small compared to the intergovernmental reflection that it has allowed (Tuominen and Kanner, 2011). The same working group prepared the 2013 ITS strategy, the 2013 National Energy and Climate Strategy and the Finnish Traffic Lab in 2014. In 2017, the Finnish Transport Code was adopted, forcing transport providers to reveal their operational information.

HSL, previously *Pääkaupunkiseudun yhteistyövaltuuskunta* (YVT) launched the first door-to-door trip planner in 2001. The service, today called **Reittiopas** (https://reittiopas.hsl.fi), integrates information on HSL public transport services and Kaupunkipyörät (city bikesharing system). The Journey planner is based on Digitransit service platform, which is an open source routing platform developed by HSL and Traficom. Maps, streets, buildings, stop locations and other urban features are provided by OpenStreetMap.

Since 2018, Digitransit service platform has also hosted national travel planning (Matka.fi). Traficom has however signaled its wish to leave the field open to the private sector or to other transport operators by the end of 2020. The law on transport services has been amended to provide new opportunities to companies providing passenger information services (Traficom, 2019).

In April 2018, HSL lunched the world's first OpenMaaS Developer Portal. HSL's open interface services include HSL's real-time public transport vehicle location data as well as a ticket sales interface for acquiring HSL mobile tickets (https://sales-api.hsl.fi/). This interface will encourage new players to enter the market.

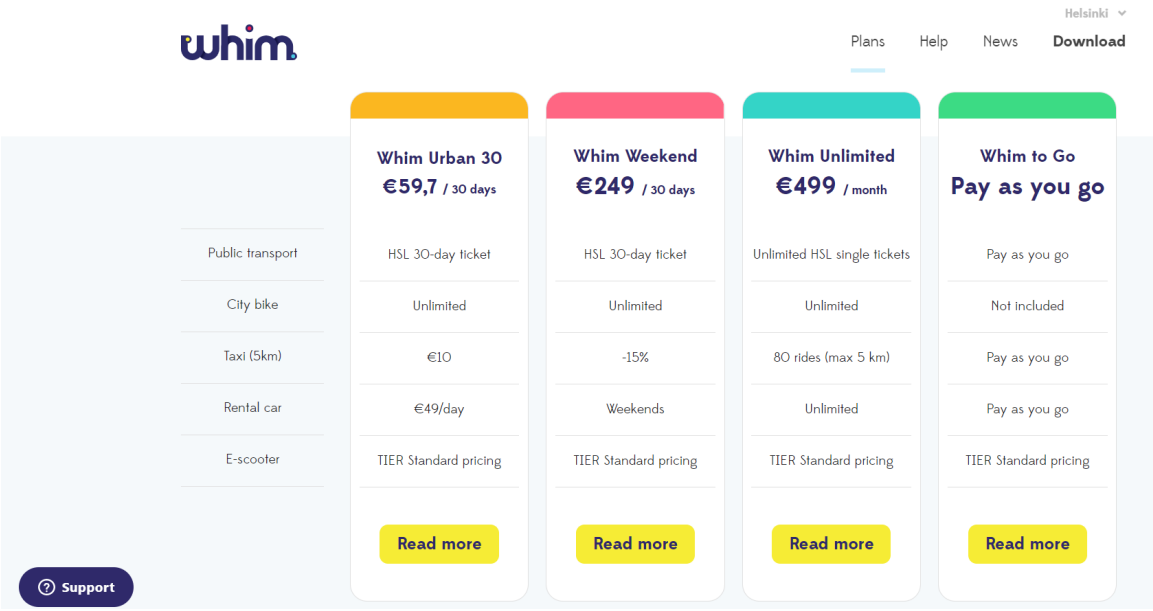
Maas Global introduced its MaaS "Whim" application in Helsinki at the end of 2016. The complete launch of the application took place in November 2017. The app is also available in Turku (Finland), West Midlands (UK), Antwerp (Netherlands), Vienna, Tokyo, and Singapore.

HSL strongly supports the creation of new innovative services through its open data policy but is not an official partner of the city. HSL does little promotion of the Whim app on its website so as for any other company. The main contribution to the project was opening its payment APIs to enable the private sector to integrate the Helsinki region public transport tickets into their mobile application. The city thus leaves room for future competition in this area. Transport Code act would have also been amended to legally require transportation service providers, including Uber, to open up their data and payment systems, paving the way for new mobility services (Haaramo, 2016).

The payment APIs also open new intercity cooperation opportunity. In a Unique European project, Tallinn and Tartu (Estonia) local public transport app can be also used in Helsinki (Eltis, 2019).

Whim mobile app allows payment for public transport (HSL), citybikes, e-scooter (TIER), taxis, carsharing and car rentals on a pay-as-you-go basis at standard prices. Users can also opt for a package ranging from €59,70 to €579 per month (Table 27). The smaller package (Urban 30) offers a 30-days HSL tickets, unlimited 30-minutes Citybike rides, discounted taxi rides within 5 kilometers and discounted car rentals. The price charged for this plan is the same as the regular price charged by HSL for a 30-days ticket only. The user therefore gets more services for his money. The larger package (Unlimited) includes 30-days HSL ticket, unlimited 30-minutes Citybikes, unlimited 2 hours carsharing rentals and 80 taxi rides within 5 km. E-scooter are always charged at standard price no matter the package.

Table 27: Whim mobility packages, Helsinki, 2020



Source: https://whimapp.com/

The first commercial Whim ride has been completed in October 2016. In 2019, more than 3 million trips were made through the app (Whim, 2019). The report of the consulting firm Ramboll reviews the first year's travel data (2018) provided by Maas Global. The results indicate that:

- Whim users are younger than the Finnish population with only 8% of people aged 66 and over. No user would be under 18 years old;
- The modal share of public transport is 63% for Whim users against 48% for residents of the Helsinki metropolitan area, as illustrated in Figure 17, which support the idea that public transport is indeed the backbone of MaaS;
- 68 % of trips made through Whim app occur where the level of service of the public transport is the most important in the city (mostly downtown);
- Whim users combine 3 times more often taxi with transit than typical Helsinki residents (9 % of taxi trips against 3 % in general population);
- Whim users travel two times more often by taxi (2 % modal share) than residents;
- Between 12 % and 15 % of CityBikes trips by Whim users would serve as a first or last mile connection with transit;
- Whim users make shorter CityBikes trips (1.9 km on average against 2.1);
- Average daily trips are about the same (3.4);
- Among mobility packages, 95 % of Whim-trips are made by PT, 3,75 % by taxi and 1,02 % by bicycle, 0,03 % by car rental and 0,001 % with carsharing. Data does not show how many walking, private bike or car trips have been made.

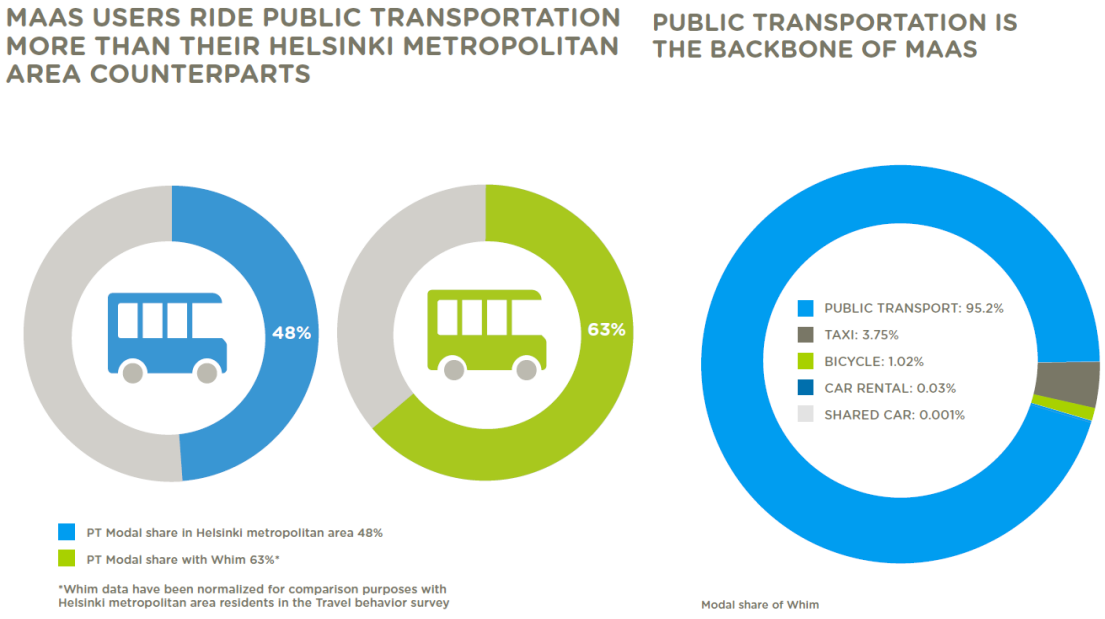


Figure 17: Impact of MaaS In Helsinki
Source : Ramboll (2019)

The report mentions some important data analysis challenges that prevent services improvement. European data privacy terms (GDPR) prevent the use of user-specific identifiers, as well as detailed information about geospatial position and temporal activities. This impacts the ability to get a clear picture about trip origins and destinations, as well as trip chains. A consent form to access the data could be implemented in the future. The data fomat also makes it impossible to know which mode of transport is used in the public network, since the same transport ticket gives access to the metro, bus, tram and ferry services.

Vienna

In 2011, the Federal Ministry of Transportation, Innovation and Technology of Austria (BMVIT) adopted its own ITS action plan, which led to the creation of a legal framework, and laid down standards. The federal government was already at an advance stage of reflections since it has been investing in the development of new system for the freight traffic and logistics sectors for 10 years. As simply summarized by the minister, Doris Bures:

> "*It is essential that the rapidly growing volume of traffic is managed in a way that is sustainable, green and socially just. Expanding public transport systems is an important step in this direction (…) The challenge now is to deploy these intelligent transport systems in real traffic. To do so, we need optimal interaction between people and technologies, a leveraging of synergies between modes of transport to offer mobility in a way that is environmentally friendly, safe, and efficient. ITS services, ranging from information to booking and standardised billing systems across different forms of mobility, make an important contribution to achieving this goal*." (bmvit, 2011)

In 2012, the Austrian Federal Railway (ÖBB) (a joint stock company owned by the Austrian state) and the Wiener Stadtwerke AG (the most important Austrian private utility company, privatized since 1999) led a consortium to develop a multimodal digital platform. The SMILE project (Simply MobILE) has been funded by the Austrian Climate and Energy Fund Austrian Research Promotion Agency (FFG). Fluidtime and NTT Data, took care of the development of the back and front ends of the MaaS scheme, which was trialled during most of 2014. SMILE pricing offered a single pricing scheme where customers are billed for what they consume. The project was terminated in 2014 due to the end of public funding (Audouin and Finger, 2019).

In 2015, Wiener Stadtwerke AG and the ÖBB decided to continue their partnership and to found a start-up subsidiary called Upstream. This new project will give birth to the WienMobil app in 2017. WienMobil makes it possible to plan, book and pay for various modes of transport. It also considers memberships previously bought with transport providers. Unlike other applications, all mobility companies in the region are represented in the application. Discounts are offered for titles purchased through the app. The app also include a visualizing tool for the walking distances and travel times.

Ubigo, from Gothenburg to Stockholm

Ubigo is a MaaS Pioneer. It was born out of the very successful pilot in Gothenburg in 2014. The company relaunched in Stockholm in 2019 in cooperation with the platform provider Fluidtime, SL and various private transport operators such as Cabonline, Hertz and MoveAbout. The app offer subscriptions "à la carte" among each service operator instead of closed bundles as it is the case for Whim. The relaunch was made possible by SL opening up for digital reselling and bundling of services and with support by the EU H2020 project CiViTAS Eccentric (UITP, 2019).

The pilot project in Gothenburg involved 76 households who paid for their mobility services upfront, while earning a bonus for making sustainable choices. Overall results indicate a reduction of walking (-5 %) and use of private car (- 50%) and an increase in all other modes, including train (+20%), bicycle (+35 %), express bus (+100%) and carsharing (+200%). At the end of the experiment, 52 % of participants had a better attitude towards bus/tram and 61 % a better attitude with respect to carsharing. Almost all participants who reported behavioral changes were satisfied, but only 50 % claimed the changes would remain. At the beginning of the experiment, about 175 people showed their interest but chose to not participate in the pilot project. Main reasons evoked were "the lack of time", the costs that was "more expensive than the current transportation solution", the fact that they "travel too little" or because another member of the family did not want to participate (Sochor, 2016).

Other mobility packages

In the Netherlands, the Flex tariffs (Start Flex, Flex and Extra Flex) allow to travel throughout the country with public transport operators (GVB in Amsterdam, RET in Rotterdam or interurbain Sprinter by NS) and other regional private operators (Connexxion, EBS et Keolis).

Helsinki city does not offer a comprehensive mobility package in the same way as Whim does (see preceding section). However, holders of an HSL pass benefit from discounts on CityCarClub's carsharing services as well as on some car rental dealers.

European Union

In 2019, the EU adopted a directive on open data which gives a legal framework for the European market. It encourages Member states to make public sector (national, regional and local) and publicly funded data re-usable. The Directive focuses on the economic value of re-use rather than on access to information by citizens. The Directive is aimed to stimulate the publishing of dynamic data and the uptake of APIs, limit the overcharging by public bodies to access their information, develop policies for open access and re-usability to publicly funded research data as well as strengthen the transparency requirements for public-private agreements. By 2021, the European Union will also adopt a list of high commercial value datasets to be provided free of charge, in machine readable formats, provided via APIs, to speed up the emergence of new technological applications. Six thematic categories are targeted: geospatial, earth observation and environment, meteorological, statistics, company ownership and mobility (EC, 2019).

2.4 Synthesis of case studies

The countries and cities selected as case studies were chosen on the basis of 5 criteria (1) their motorization rate; (2) the volume of GHG emissions produced by the transport sector; (3) the modal share of sustainable mobility services; (4) their presence within a political federation; and (5) the recommendation of Transport Canada. Ten case studies were carried out: Berlin (Germany), Vienna (Austria), Amsterdam (Netherlands), Helsinki (Finland), Stockholm (Sweden), Copenhagen (Denmark), Sydney (Australia), Tokyo (Japan), Seoul (Korea) and Singapore.

New shared mobility services are essentially offered by the private sector while the public sector maintains its authority over public transport. Private companies increasingly operate in several countries. Cities are often used as a test bench for business models destined to be replicated internationally. Most selected cities are international economic hubs in the transport and ICTs sectors. The most active countries in the shared mobility market are, each in their niche, the United States, Germany, the Netherlands, and China.

It was proved difficult to compare transport systems since very little data on operations and current use of services has been found to be available and comparable, especially for private companies. The data collected seem to indicate that a greater supply of shared mobility services tends to reduce individual car ownership. However, there is no single model of success. Some cities rely more on a diversified and extensive public transport network, while others strongly promote active transportation modes. Car-related services, in particular carsharing, seem to be more present where policies restricting automobile use and possession are more stringent. Which helps promote social acceptability.

Motorization tends to increase with wealth. Cities with an above-average household income also tend to have a relatively higher level of passenger cars per inhabitant. Smart urban planning policies, including home ownership strategy combined with transit-oriented development, as well as quality infrastructure and transport services can greatly contribute to curb car use. Selected cities generally support the idea of a more compact city and are committed to increasing the density and diversity of their urban space.

Cities do not have the same means to achieve their goals. The separation of legislative, taxing and spending powers, between each unit of government (national, regional, and local), varies from one country to another. Most selected cities have a special status within their country which grants them more powers than usual cities. These powers can take the form of additional car management tools (e.g. congestion tolls, emissions-free zones, control over road capacity and investment projects) or extended powers in areas typically reserved for higher levels of government, such as health or information and communication technologies (ICTs). Science is increasingly clear that active mobility positively contributes to public health. In countries where these responsibilities are combined, there is more research on cross-economic benefits and a greater willingness to invest in collective and active transportation infrastructures.

Finally, we observed that cities that we selected as leaders in sustainable mobility do not necessarily have a multimodal mobile application. This observation supports the idea that if access to information greatly improve the attractiveness of services for users, a fruitful

ecosystem for sustainable mobility requires an extensive set of winning conditions, including reliable transport services, quality infrastructures and smart planning policies.

Table 28: Case studies summary

	Helsinki	Stockholm	Copenhagen	Amsterdam	Berlin	Vienna	Sydney	Tokyo	Seoul	Singapore
Cars per 1,000 hab.	391	389	360	371	339	390	500	329	271	116
Public transit vehicle-km per capita (VKM)	108	144	143	NA	130	99	50	106	NA	84
Equivalized household income (K$, USD)	29	36	30	29	23	29	43	27	22	ND
Built-up area (m^2 per capita)	209	160	265	293	216	297	334	124	55	35
Share of national youth population (%)	27	24	36	16	6	32	20	27	47	12
Transit services										
Metro										
Tramway / Light rail										
Bus										
Commuter train										
Ferry										
Microtransit										
Active modes										
Bikesharing (official)	SB		SB		H	SB		SB	SB	FF
Bikesharing 2			H	H	FF	H	FF			FF
Bikesharing 3				FF	FF	H				
Bikesharing 4				FF	H					
Bikesharing 5				FF	H					
Scootersharing 1	FF	FF	FF		FF	FF	FF			
Scootersharing 2	FF	FF			FF	FF				
Car-related										
Carsharing 1	SB	FF	FF	SB	FF	SB	SB	SB	FF	SB
Carsharing 2			FF	FF		FF				FF
Carsharing 3			SB	FF						
Carpooling (several companies)										
Ridehailing 1										
Ridehailing 2										
Ridepooling										
Taxi (several companies)										
Car rental (several companies)										
Multimodal App										
Mobile app 1										
Mobile app 2										

Source: Chaire Mobilité (Polytechnique Montréal)

3 Conclusion

The transport sector has experienced unprecedented development over the past decades. It has been propelled both by the public and the private sectors but also by a growing adherence of the population to the sharing economy and the emergence of peer-to-peer services. A whole new vocabulary, on which there is no consensus yet, has appeared to describe the new mobility services: Mobility-as-a-Service, transport-on-demand, ridesourcing, micromobility, integrated mobility, etc. This study presented a state of knowledge based on scientific literature and field practices.

Shared mobility can be widely extended to all modes and services of transport other than driving a privately-owned vehicle. Innovative business models are constantly developing at the intersection of existing services. This study proposes a typology of existing services to better understand the multiple dimensions of shared mobility.

The scientific literature indicates that all shared mobility services contribute to multimodality, which means they increase the flexibility of an individual to use different modes of transportation at different points in time. However, they contribute unevenly to collective goals such as reducing car ownership and vehicle-kilometers traveled (VKT). Carsharing would have the greatest impact with, of course, public transport, which is considered, by all experts, as the backbone of the shared mobility system. Without public transit all the other services would struggle to exist. Although essential to multimodality, taxi and ridesourcing services would have the least important structural effects, their relatively high cost making their use more occasional and often for trips where no other alternative exists. Concerning intermodality, defined as the use of at least two transport services or modes during a single trip, it appeared that shared mobility services could complement or compete with each other depending on the context of the trip. There is a strong competition of new mobility services in city centers, while the suburbs still have few alternatives to the automobile. This raise concerns on the ability of shared mobility to achieve environmental targets if urban sprawl continues. In Canada, long-distance travel is another market for which there are few alternatives to the car, although options exist. Competition between services is still very little documented in the literature as we discuss more and more their integration.

In its simplest definition, Mobility-as-a-Service (MaaS) refers to the integration of several forms of transport services accessible on demand. The general idea is to offer a competitive alternative to the automobile by allowing users to seamlessly get from point A to point B, using various modes, accessible through a single multimodal platform. The concept is still in its early stages with several pilot projects underway around the world. Most MaaS platform, such as Google Maps App, only offer travel information (e.g. trip planning, real -time traffic and price information). Some also offer booking and payment services (e.g. Transit, WienMobil). Only Whim (Finland) and Ubigo (Sweden) currently offers the possibility of combining mobility expenses in a mobility package. In fact, it must be noted that many experiences of mobility packages exist around the world, such as Portland's Transportation Wallet. These are simply not offered through a mobile app.

Indeed, a lot of emphasis has been placed on the technological aspects of integrating mobility services, while MaaS should rather be conceived as an ecosystem. As rightly pointed out by the European Commission "*New technologies alone will not spontaneously*

make our lives better without upgrading our transport systems and policy". Several conditions must be met to allow an individual to move from point A to point B seamlessly: reliable transport services, especially a strong transit system; quality pedestrian and cycling infrastructures; smart urban planning facilitating trip chains; legislation and data governance fostering fruitful public-private partnerships, public consultations ensuring that the system meets the needs of users and above all clear societal goals to guide decisions. Several business models for the MaaS platforms exist, most experts lean in favor of a public owner or an independent open platform. The data generated by these platforms have an important commercial value that could benefit the greatest numbers if the winning conditions for reuse are met. The European Union is working on an open data directive.

The future of mobility looks very promising:

- ICTs deployment has greatly accelerated innovations in the transport sector. Today's users benefit from an unprecedent variety of mobility services, that are more flexible, comfortable, and user-friendly than ever in the past. In this regard, the private sector has proven to be a valuable ally in the development of innovative business models and solutions.
- Case studies demonstrate that there is no one-size-fits-all model to achieve sustainable mobility goals. Some cities are achieving excellent results by focusing on public transport while other favored active transport. Car-related services are important complements, especially in less densely populated and more dispersed urban areas. They can also promote the social acceptability of measures to restrict the possession and use of the personal vehicle.

However, some concerns must be raised with regard to the evolution of the market:

- It must be recognized that the market has evolved faster in recent years than our capacity to understand it. There is high pressure to accelerate the integration of services while neither the interactions between the services, nor the real benefits they provide to the consumer and even less the profitability of new mobility providers, are fully understood.
- Governments must now question themselves on how to frame this market, in a way that will preserve the commercial freedom necessary to promote innovation while encouraging healthy competition among players and that will not harm public transport systems either.
- Public policies must be directed towards clear societal goals whose progress must be assessed using established performance indicators. These societal goals and indicators are largely non-existent at the moment. Available of data from service providers is one key to being able to objectively measure each one's contribution.
- MaaS concept is sometimes described as a non-competitive bundling of services, but it must be kept in mind that public budgets and market shares are in their essence financial cakes that organizations compete for. Public funds should continue to support, in priority, public transport systems. Without as strong public transport backbone, all other shared mobility services will struggle to exist.
- A very important emphasis is placed on the need to increase the efficiency of transport networks in order to compete with the automobile. Some experts point

out that new mobility solutions, in particular car-related services, are making cars even more appealing, thereby luring passengers from public transport.

- The issues surrounding equity and accessibility of services (physical, technological, and financial) are also almost non-existent in the discussion surrounding the MaaS concept.
- The future of mobility should not be reduced to its technological aspects. Reliable and frequent transportation services, smart urban planning practices and infrastructures are even more essential to its success
- New mobility platforms, which combine many mobility services and providers, constitute a major innovation and a significant improvement in travel conditions for consumers who can now compare their options in the blink of an eye. There is a risk that these platforms drift towards anti-competitive practices if they are not properly framed. Data governance (security, reciprocal sharing of information between the public and private sectors, independence of algorithms) as well as market entry conditions and pricing strategies must be closely monitored to maintain healthy competition between players for the benefit of consumer.

The winning conditions for setting up a successful MaaS ecosystem can be summarized by the following recommendations:

- Clear social goals aligned with population's needs and environmental targets;
- Performance indicators, encompassing all public and private partners, making it possible to assess the achievement of these social goals;
- Active monitoring, planning, and funding from public sector favoring a strong transit system surrounded by valuable mobility providers;
- Good quality infrastructures providing efficient, safe and comfortable walking and cycling conditions;
- Smart urban planning practices linking not only employment and residential areas through sustainable transport mode, but also recurring daily activities such as school, daycare, and grocery store, in a way that simplifies travel chains and thus reducing the need to use a car to the source;
- Wide accessibility to the internet, Wi-Fi and mobile phones;
- Genuine regulations leaving space for the private sector to innovate, but preserving market competitiveness and incentivizing companies to produce a value-added for the consumers;
- Intergovernmental governance eliminating administrative and budgetary silos;
- Strong data governance with reciprocity and transparency regarding data sharing agreements in public-private partnership as well as data standardisation guidelines, independence of algorithms and high requirement regarding cybersecurity.

The COVID-19 puts an historic brake on the transportation industry. Some believe that the fear of a new pandemic could lead to the death of shared mobility markets. The future could be full of surprises. The attacks of September 11 and the wave of terrorist attacks that followed in the airport could have seriously damaged the airline industry and yet, until recently, million of flights took off every year. Three things are certain, however. First, like airports that have increased their security measures, it is likely that the shared mobility industry will have to adapt to new standards of hygiene and social distancing. Second, the COVID crisis will have precipitated the fall of certain companies that were already on the edge of bankruptcy. The current situation will allow beneficial reflection time to better understand the competitive and complementary relationship between services as well as the benefits they bring to consumers considering the heterogeneity of preferences and accessibility needs. It would also be desirable to define more clearly the main societal objectives to be achieved and to set measurable targets. Third, it is expected that COVID-19 will lead to budgetary austerity and financial insecurity for households. Much public spending is currently carried out in budgetary silos. Greater collaboration between and within levels of government to consider the cross-benefits of investment projects could reduce the overall pressure on public finances. This brings an opportunity for collaboration between players in the transport, housing, energy, communications, and technology sectors to develop projects with a higher value-added for the community, the consumer, and the taxpayer.

4 Annexes

4.1 Shared mobility services: literature review

This section offers a brief review of the literature for each shared mobility service. An emphasis is put on understanding the sociodemographic characteristics of its users, its benefits in terms of reducing motorization rates and VKT as well as its relationship with other transportation modes. Before all, the first section discusses the emotional attachment to the car and its relation to ownership.

4.1.1 Emotional attachment and car ownership

An important preliminary question is to understand where the attachment to the automobile comes from since car ownership is considered as the greatest obstacle for shared mobility. A car parked in front of the house changes habits and choices in favor of this mode of transport: on the one hand, because of its user-friendliness and its accessibility and on the other hand, because of its important fixed costs which the consumers try to pay off by using it more often and travelling greater distances. Difficulties in estimating the total costs of the automobile, as well as marketing strategies to increase emotional attachment to the car, are other important explanatory factors (UITP, 2019).

Based on a review of multidisciplinary writings, (Beaulieu et al., 2018) conclude that dependence on the automobile in Quebec is attributable to affective determinants (e.g. pleasure provided by strong sensations while driving) and symbolic determinants (e.g. self-esteem, prestige, social norms). Resistance to modal shift is also explained by socio-demographic, meteorological and technical factors (e.g. distance, duration, connectivity, and tortuosity of trips). Due to its high costs, both financial and non-financial (e.g. time spent in congestion, stress), car ownership and use are increasingly questioned. Still, little actions are taken to induce a modal shift.

The authors also explore the literature associated with two types of drivers to better understand the automobile addiction issue: car enthusiasts and generation Z.

- **Traditional car enthusiasts** consider the car as the only possible mode of transport. They are very reluctant to try other modes and demonstrate a weak commitment to sustainable mobility. They typically choose places of residence outside the big cities where there is an abundance of green space. Public policies have little or no potential to affect their mobility choices.
- The **flexible car enthusiasts** demonstrate greater neutrality vis-à-vis other modes of transport, although they mainly use the car. They also prefer to live outside city centers, do not generally support the imposition of environmental taxes and believe that road capacity increase can reduce congestion. Despite sometimes negative reactions, structuring transit projects can contribute to raise their awareness and engage them in a modal transition. In the Quebec City region, generally considered to be less favorable to public and active transportation, a survey on 5,209 people conducted by the “Institut du Nouveau Monde” revealed that 65% of respondents strongly agree or somewhat agree with the implementation of a structuring public transport network for the agglomeration of Quebec and 66% strongly agree or rather agree with the creation of new dedicated lanes for transit. A better public

transport supply combined with more restrictive policies regarding the ownership and use of the car could therefore have positive effects on their travel behaviors. They are also inclined to adopt electric vehicles.

- **Generation Z**, born after the year 2000, are digital natives. Arriving at its majority, this connected generation tends to attach more importance to experiences than to material possession. They display a lower car ownership and driver's license rates than previous generations. This paradigm shift has greatly stimulated the growth of the sharing economy market and has prompted car manufacturers to develop shared vehicle systems for them (e.g. FordGoBike). However, even if the smartphone is a greater symbol of freedom than the automobile for this generation, ICTs would not be the determining factor. The same goes for ecology. Although young people are conscious of environmental issues and the impact of the automobile, it is above all that the lost of stature of the automobile as a symbol of social success. Its cost and the inconvenience of its use in the city would appear in the foreground of the paradigm shift. This means that this change affects mainly young urban people. The trend observed is way more timid outside the central cities (Vincent-Geslin et al., 2016). We can also expect a catch-up effect in a few years for three reasons. First, car use tends to increase with income and income increases with age. Second, use of the automobile is more pronounced in households with children and this generation is not yet at this stage of life. Finally, home ownership goes largely through the "drive until you qualify". Among those who would like not to have a car in the future, some may not be able to make this choice because of the urban environment in which they will have the financial means to become an owner.

Beaulieu et al. (2018) also identify leverages to induce changes in mobility behaviors:

- Car restriction policies (e.g. fuel tax, parking fees, parking space removal);
- increase in public transportation services (e.g. dedicated lane);
- investments in infrastructure facilitating active transport;
- shared mobility services availability;
- information and communication technologies (ICTs) in support of multimodal trips (real time information).

The implementation of car restrictive policies, together with ICTs, would also encourage a different lifestyle (e.g. online shopping, teleworking). The impact of teleworking is mixed, since it would also encourage some workers to settle further away from the city centers, which may increase the distances travelled for other trip purposes for these people.

4.1.2 Bikesharing systems

Based on an online survey among bikesharing service users in four North American cities (Montreal, Minneapolis-Saint Paul, Toronto, and Washington D.C.), Shaheen et al. (2013) observe a decrease in automobile use. In Montreal, 37% reported using their car less often and 44% said they used the taxi less often. Also, 41% said they combine shared bikes with public transportation to complete trips they would have otherwise made by car. In another study based on the same survey, Shaheen et al. (2012) note that 12% of respondents have sold or given a vehicle or are considering doing so. Bikesharing subscription would have contributed to this decision in 55% of cases. In another study based on the same survey, Shaheen et al. (2012) note that 12% of respondents have sold

or given a vehicle or are considering doing so and that the bikesharing subscription would have contributed to this decision in 55% of the cases.

Bikesharing can also compete with transit. Since it is an inexpensive, fast, and direct mode, it can replace public transport for short trips. It can also be an effective solution to avoid transit transfers and detours which would lengthen the duration of the trip (Campbell & Brakewood, Martin & Shaheen, 2014; Shaheen et al., 2013). A significant portion of trips made by bikesharing would thus have otherwise been made by public transport or on foot (Fishman et al. (2014), Fuller et al. (2013), Jiangyin, China, Tingting et al. (2011)).

Fuller et al. (2013) note, however, that this is not a “strict” modal shift. On the contrary, bikesharing largely encourages multimodality. Even if it can reduce specific types of trips, people surveyed generally see bikesharing as an extension of public transportation. The transition from one mode to the other is particularly visible during inclement weather which discourages the use of active transportation or, inversely, transit service disruption (Lepage, 2019).

Due to their small sample size, surveys make it difficult to assess systemic impacts. The results of Ma et al. (2015), based on passive and longitudinal data, indicate that a 10% increase in annual bikesharing ridership would have contributed to an increase of 2.8% in metro ridership in Washington. In New York, Campbell and Brakewood (2017), on the contrary, observe a 2.42% decrease in bus trips for each thousand shared bike anchors. One possible interpretation of these contradictory results is that bikesharing complete rail, bridging the first and last kilometer, while it competes bus on journeys which are on average shorter. In Washington, data support this observation by indicating that it is people in dense urban neighborhoods who tend to reduce their use of public transport, while bikesharing subscriptions increase the use of public transport in the periphery (Ma and Knaap (2019) .The reduction observed in the city center could be partly attributable to the saturation of the network and a decrease in user comfort.

4.1.3 Carsharing systems

Literature on carsharing used to focus essentially on station-based systems. With the advent of free-floating services, we have seen more contributions examining such type of services, trying to understand the difference in features, users and impacts between them.

All literature reviewed agrees that carsharing, both station-based service and free-floating vehicles, leads to a decrease in car ownership (Lane, 2005; Le Vine & Polak, 2019; Martin et al., 2010). The results of an online survey of members of 11 North American carsharing companies reveal that even if 60% of households that subscribed to the service were initially non-motorized, the average number of vehicles per household in the sample was halved (Martin et al, 2010). Presumably, in the absence of a carsharing service, some of these households would have made the choice to buy a vehicle, which would have increased their use.

One thing leading to another, it also contributes to reduce VKT, GHG emissions, congestion, and parking issues. In Quebec, Communauto services impact have been estimated to be 1.2 ton of CO_2 emissions per year for each user in addition to substituting 8 private vehicles for each shared vehicle put into circulation (Tecsult, 2006). These

benefits could not materialize without complementarity with other transport services. Only 2% of carsharing members use a carsharing system for commuting purposes. This implies that a large proportion of daily trips are made using other modes of transportation (Wielinski, 2014).

The results regarding the interaction between public transit and carsharing vary widely depending on the context. A significant part of people surveyed declared that they used public transport less after registering for the service (Trépanier et al, 2013; Clewlow, 2016). Free-floating systems, allowing a one-way trip, would give more flexibility to make certain trips to the workplace or school, which would take market share from public transport. But, for the same reason, they can also be used as a complement for the first-last kilometer connection. Occasional leisure, shopping and visiting friends or a relative remain the main reasons for subscribing to a carsharing system.

For station-based services, literature indicates that users are fairly young (25 to 45 years old), part of small households with few children and have a higher level of education. Gender and income do not figure systematically among the explanatory factors. In Quebec, analyses of Communauto data on weekly transactions indicate two main types of users: high-frequency users (14%) and low-frequency users (86%). About half of the users would also have a relatively stable use of the services throughout the year, whether for long distance journeys (17%) or short distances (33%). Compared to traditional car owners, trip chain of carsharing users display more frequent and closer stops, signaling a certain intention to maximize car usage time (Wielinski, 2014).

4.1.4 Ridesourcing

The arrival of Uber in 2009 created a huge stir in the taxi industry all over the world. Not being subject to the same regulatory requirements, particularly regarding permits (medallions), service areas and prices, ridehailing services are seen as unfair competition. Some cities have welcomed this new competition and reformed the traditional taxi industry accordingly (e.g. New York, Portland). Other cities or countries have instead chosen to ban the services (e.g. Germany, Colombia) or to put in place regulations encouraging the company to exit the market itself (e.g. Barcelona). Several analyses have shown a decrease in taxi trips from the moment Uber entered the market (Chang, 2017). The decrease observed however not always considers the potential effect of motorization, PT or other shared mobility services during the same period. Because of their lower prices, supporters suggest that ridehailing services would attract customers who would not otherwise have used taxi services. If this market expansion assumption is true, it means that these new customers were either automobile owners or PT users.

The arrival of UberPool and Lyft in 2014 in the United States have increased the concern about transit ridership diversions. Ridesharing (also called ridesplitting or ridepooling) services are cheaper than traditional taxi services and even ridehailing services since the algorithm maximizes vehicle occupancy by allowing the driver to drop on and drop off passengers at different points on the route. For certain trips, the service is more advantageous than public transport, both in terms of time and price (compared to a single ticket price). Supporters suggests that ridesourcing, be it ridehailing or ridepooling, plays a positive role in filling “mobility gaps” and encourages car-free lifestyles.

Ridesourcing services, also called Transportation Network Company (TNC) in regulatory purposes, poses significant challenges for researchers and policymakers as there is limited information and data about how these services affect transportation decisions and travel patterns.

Schwieterman and Smith (2018) explored the competitiveness of ridesplitting services compared to public transportation services in the Chicago area. The study compared only the differential in trip times and did not analyse the modal real choices since no data was available. The results indicate that ridesplitting seems to have relatively few advantages for downtown-oriented trips or when transit riders are not burdened with transfers or significant walking distances. On the other hand, they could constitute an important new alternative for underserved and lower patronage areas where the time differential with public transportation can exceed half an hour.

Rayle et al. (2016), arrive at a similar conclusion showing that the majority of trips made with TNCs would have taken more than twice as long if they had been made by public transport. Based on a complementary small telephone survey, the authors also concluded that about half of the TNCs trips would have been taxi consumers otherwise. The results do not show any positive impact on car ownership, while the impact on the mileage traveled is uncertain.

Feigon and Murphy (2018) were able to obtain origin-destination hourly data from a "large TNC company" (whose name is not mentioned) for the period 2010 to 2016 as well as survey data for 5 American regions. The results indicate that (1) TNCs would not have a significant impact on public transport during rush hour (2) TNCs are used more occasionally than PT and personal cars which fulfill routine mobility needs (3) shorter total trip time, including waiting times, is the main reason for substituting PT trips (4) TNCs are also used by consumer as a complement of PT to bridge the first and last kilometer (5) TNCs help to reduce car ownership. Based on survey answers, the sum of postponed or canceled car purchases as well as car sales without replacement would have been greater than car purchases among TNCs users. The authors also mention that it would help reduce the distances traveled by car.

Hall et al. (2018) used data from Google Trend to estimate the penetration of Uber in 339 American cities. They believe that Uber would have contributed to a 5% increase in ridership after two years and the effect would be growing over time. The complementarity effect would be greater in small cities where the PT network is less developed. The authors also mentioned an increase in commuting times, which they believe confirms that Uber increases traffic congestion.

Graehler Jr et al. (2019) argue that part of the decline or stagnation in the use of PT in large North American cities is attributable to TNCs. The authors calculate that service should be increased by 25% to offset the decline in PT ridership due to the expansion of TNCs. They also believe that TNCs will contribute to increase congestion problems in the future.

Clewclow and al. (2017) present findings from a travel and residential survey deployed in seven major U.S. cities (Boston, Chicago, Los Angeles, New York, San Francisco, Seattle and Washington), in two phases from 2014 to 2016, with the purpose to provide insights on the adoption and travel behavior impacts of ridehailing. A total of 4,094 completed

responses were collected, with 2,217 from dense urban neighborhoods and 1,877 from suburban locations. Results indicate:

- 15 % of adults personally use ridehailing services in and around home city, 6 % when travelling away from home and 9 % with friends without having the app;
- Ridehailing adoption decreases with age, with 4 % among those aged 65 years and older, 36 % among 18 to 29 years old;
- Adoption increases with education level (25 % for bachelor vs 11 % for high school grade) and income (33 % for $150,000 or more vs 15 % for less than $35,000);
- There are more adopters among city dwellers (29 %) than in the suburbs (14 %);
- A quarter (24 %) of adopters use it on a weekly or daily basis;
- There is an overlap in the adoption of carsharing and ridehailing, 23 % of ridehailing users are (9 %) or were (14 %) members of a carsharing compare to 3% among non-ridehailing users;
- Parking is the main reason to use ridehailing instead of driving (37 %), followed by avoiding drinking and driving (33 %);
- A larger proportion of “transit only” travelers have no household vehicle (41 %) than “transit and ridehail” travelers (30 %);
- Among non-transit users, there is no difference in vehicle ownership rate between ridehailing users and traditionally car-centric households;
- Slow services, not enough stops and no transit services available are the most important reason to ridehail;
- The majority of ridehailing users (91 %) have not made any changes in vehicle ownership and those who have reduced the number of cars they own have substituted some trips with ridehailing: net impact on VKT is unknown;
- Ridehailing attracts Americans away from bus (6 % reduction) and light rail (3 % reduction), but serves as a complementary mode for commuter rail services (3 % increase);
- If ridehailing was not available only 1 % would have taken a taxi service, 22 % would have made fewer trips, 21 % would have drive, 18 % used a carpool services, 15 % taken transit, 17 % walked and 7 % cycled.
- Authors globally conclude that ridehailing services are currently likely to contribute to growth in VKT in major cities.

In Toronto, the data from the 2016 Transportation Tomorrow Survey (TTS) indicates that the modal share of ridehailing would reach 0.93% compared to 0.91% for taxis. This share would however be underestimated. The data indicate that users are mainly young adults, with full-time employment status and belonging to higher income classes. Most users (81.1%) have a driver's license, half have access to at least one car in their household (50,9 %) and half (49.4%) have a monthly transit pass. A significant portion of the services are used in the evening or at night to go out, return home or to go to work. The data finally indicate a marked decrease in automobile use among young people aged 20 to 29 years old between 11pm and 5am. The modal share of the automobile went from 66.4% in 2001 to 21.4% in 2016, mainly to the benefit of active modes (291.1%), ridehailing (24.1%) and public transport (20.3%). Ridehailing, and more generally multimodality, may reduce drunk-driving (Young and Farber, 2019).

The variety of results seems above all to indicate an urgent need for data to establish the best policies regarding the local peculiarities of transport systems and population needs.

4.1.5 Scootersharing

Scootersharing systems have appeared in many cities within the last year. If it allows to freely roam congested streets, this new micromobility is far from achieving unanimity, namely among city planners for whom they presented a significant management challenge. The lack of regulations in certain cities has led to parking problems, street sharing issues (e.g. illegal sidewalk riding) and caused some accidents. It must be said that not all cities have the legal powers to properly frame these new vehicles. Auto insurance issues, for example, are typically the responsibility of the central government. Some cities, such as Montreal, have actually decided to stop this experimentation (Radio-Canada, 2020.

In terms of research, we have little perspective to measure their impact on mobility. A survey of 4,300 users in Paris, Lyon and Marseille indicates that most users are tourists. Only 7% of users use them daily. In the absence of a scooter, only 8% would have taken a taxi or a car. Almost half (47%) would have preferred walking, 29% public transit and 9% cycling (Krier et al., 2019).

A survey of 3444 scootersharing service users and Portland residents indicates that most users (62%) are men, aged 20 to 39 (69%) and have a college degree (40%). Only 2% use it occasionally, 26% 1 to 3 times a week and slightly less than half (41%) on an occasional basis. The main reasons for use are for fun / recreation / social / entertainment or to go to a restaurant. About 18% of users reported using it first to go to work. Also, about 5% would use it to reach a public transport station. Without a scooter, 36% would have walked, 34% would have taken a car (personal, carsharing or taxi), 10% would have taken public transport, 8% a bicycle (personal or shared) and 7.5% would not have made this trip. The largest difference is in taxis: 44% of people said they reduced their use against 0.7% who said they increased it. The same goes for the use of a personal car, 38.5% indicated that they used it less compared to 1.5% who indicated that they used it more. Also, 5.7% of users would have reduced the number of cars they own thanks to the scootersharing system. Only 34.5% of users were aware that scooters are not allowed to ride in the street (PBOT, 2018)

4.1.6 Autonomous vehicle

The issues related to automated and connected vehicles are huge, ranging from logistics and safety to ethical issues. This section reports very briefly the European Commission observations on the subject (EC, 2019)

Wages occupy an important part of the production costs of most enterprises. The same is true for the transportation sector. Some authors estimate that automated vehicles can cut the cost of travel by as much as 80%, which in turn could drive up VKT by 60 %.

Under the assumption that the price of automation drops sufficiently to allow for mass-market introduction, this would considerably modify the cost ratios of travel options and mobility behaviors. Likewise, a decline in the demand for public and active transportation

mode would be observed. For car owners, not to mention the possibility of offering ridehailing services at any time of the day when the car is not used, it may be cost-efficient to return the vehicle to the point of origin rather than paying for downtown parking. The effect on motorization rates would ultimately depend on vehicle prices and income prospects. On the bright side, automation could help free up parking space in city centers. Automated shuttles will also contribute to the development of an efficient and affordable microtransit service. Salaries generally account for a significant portion of operating costs. In the long term, with the decrease in technological costs, it could be profitable for public transport authorities to invest in these solutions. They will however raise social issues on wages and jobs.

4.2 European Union

The European Union (EU) formally exists since 1999 although cooperation treaties among countries have evolved since 1951. Its goal is to promote peace and enhance economic, social, and territorial cohesion among members. In 2020, 27 European countries are members of the EU, except for Switzerland, Norway, Iceland, the United Kingdom (since January 2020) and south-east European countries (Bosnia, Albania, Kosovo, Macedonia, Serbia, and Montenegro). Also, 19 countries use the Euro as a currency since 2002 and 22 participate in the Schengen Area, which gives the freedom of movement of people since 1995.

4.2.1 Government structure and separation of powers

- EU has the legislative, executive, and judicial bodies necessary for the administration of the powers which have been delegated to the Union. These powers are restricted to preserve the sovereignty of the Member States and the democratic relationship with their constituents.
- To be approved a law requires the majority. The unanimity is however essential for laws affecting taxation. This is the reason why there is no carbon tax at the EU scale. A border carbon tax, which would enact a new tax on products from countries that are not working to reduce their emissions, including the United States, is under discussion (Times, 2020).
- Laws, passed jointly by Parliament and the Council and vote by majority, can however bring significant and mandatory changes in Member States' policies in a wide range of areas such as transport, energy, environment and consumer protection (Bailleux and Dumont, 2015; Parlement européen, 2020).

The most important bodies of EU are:

- The **European Council** is formed by the heads of state or government of the Member States and sets out the general political guidelines.
- The **Council of European Union**, together with the European Parliament, based on proposals submitted by the European Commission, adopts EU legislation. The Council consists of a representative of each Member State at ministerial level.
- The **European Parliament** is the democratic body of the EU. It is composed by 751 representatives (750 Members plus the President) democratically elected by the EU's citizens. In addition, the representation of citizens is "degressively

proportional", with a minimum threshold of six seats per Member State and a maximum of 96 seats. Members do not sit in national delegations, but according to their political affinities in transnational groups. Parliament takes part in the adoption of the Union's legislation in co-decision with the Council.

- The **European Commission** (EC) has the monopoly over legislative initiative and important executive powers in policy such as international trade. It is the principal executive body of the EU and it is formed by a College of members composed of one Commissioner per Member State. The EC oversees the application of Union law and respect for the Treaties by the Member States.

To reach its objectives, the EC has three tools at its disposal:

- **Legislative initiative** allowing it to propose laws that will, once adopted by the Council and Parliament, required Members States to act;
- **Budgetary initiative**, such as funding programs;
- The power of **recommendation and opinion** which is a limited initiative power in the constitution that allow the EC, among other things, to set policy platform and generate debates among members, but also to consult cities and give them a tribe to raise some local issues. As part of the tools, a **Green Paper** is a document published by the EC to stimulate discussion on given topics.

4.2.2 Green paper

In 2007, EC adopted a Green Paper which set a new European agenda for urban mobility. In view of the economic importance and the problems with urban transport, a consensus has emerged that EU transport policy needed to facilitate the search for solutions:

- In 2010, the Europe 2020 Strategy for smart, inclusive, and sustainable growth highlighted the importance of urban dimension of transport.
- The 2011 Transport White Paper sets the goal to phase out fuel cars in urban areas by 2050.
- In 2013, a detailed understanding of the problems faced by citizens travelling in urban areas and of the potential support for different approaches to dealing with these problems was required. The Commission therefore proceeded to 27.680 face-to-face interviews (EC, 2013).
- In 2013, the Urban Mobility Package addressed procedures and financial support mechanisms, road user charging and access restriction schemes as well as best practice guidelines to better monitor and manage urban freight flows. It also reinforces its supporting measures by:
    - Sharing experiences, showcasing best practices, and fostering cooperation;
    - Providing targeted financial support;
    - Focusing research and innovation on delivering solutions for urban mobility challenges;
    - Involving the Member States and enhance international cooperation.

4.2.3 Legislative initiatives

- The European Union intervenes in air quality and polluting emissions since the 1970s (EC, 2018b).
- The EC adopted in 2013 a Clean Air Policy Package. The policy is based on three main pillars, the establishment of: (1) air quality standards, (2) national reduction targets by 2019 and (3) standards for the main sources of pollution, including vehicles automobiles and fuels.
- In 2015, EU ministers adopted a Declaration on Cycling and as a result, the Commission is working to further integrate cycling into the multimodal transport policy.
- The Digital Single Market Strategy sets out the EC's aim to make more use of ITS solutions and this is supported by documents such as the ITS Action Plan, and activities like the coordinating action such as the C-Roads Platform.
- Member States are encouraged to promote Sustainable Urban Mobility Plans (SUMPs) at the national level, and to provide their local authorities with adequate support and legislation. To empower towns and cities to develop a SUMP, EC raise awareness through training courses, good practice examples, networking opportunities, and by providing funding (Eltis, 2020b).

4.2.4 Budgetary initiatives

- In December 2019, EC presents the European Green Deal to the Council and the Parliament. It is a roadmap to make Europe the first climate-neural continent by 2050 and covering all economic sectors, including transportation and ICTs. The EC was on his way to propose a "European climate law" in March 2020. According to EC, meeting the objective will require €260 billions of additional annual investment (1.5% of 2018 GDP), from the public and private sectors. EC recommends that 25% of the EU's long-term budget be dedicated to climate action (EC, 2018b).

4.2.5 Observatory and pilot projects

- In 2002, the EC lunched the project **CIVITAS**, a network of cities dedicated to cleaner, better transport which has tested and implemented over 800 measures and urban transport solutions as part of demonstration projects in more than 80 Living Lab cities Europe-wide. The website offers a variety of tools to helps local authorities make better informed decisions including an online database, a learning center, publication, and a resources library. Information is classified by topic, one of them concerning "car-independent lifestyles".
- Created more than 10 years ago**, Eltis** is now Europe's main observatory on urban mobility. It is financed by the European Commission's Directorate General for Mobility and Transport. It provides news on urban mobility, events, fact and figures, guidelines, information about funding, legislation and policies, case studies and other tools.
- In 2017, the European Commission has granted funding of € 3.6 million to the research project **MaaS4EU** (Mobility as a Service for Europe). The main goal is to

provide quantifiable evidence, frameworks, and tools, to remove the barriers and enable a cooperative and interconnected EU single transport market for the Maas concept. The project is coordinated by the company Intrasoft International, a leading European IT Solutions and Services Group since 1996. It brings together three universities (College London, Wolverhampton, Aegean), transport agencies and private sector including MaaS Global Oy. The project will provide quantifiable costs and benefits in 3 pilot cases (Manchester, Luxembourg-Germany border area and Budapest), demonstrating the concept in the fields of urban, intercity, and cross-border trips. The project will end in May 2020.

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