Mobility as a Service
Solution to Urban Mobility Problems?

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January 19, 2021

Abstract

Mobility as a Service (MaaS) systems are an emerging trend as a response to growing mobility issues in urban areas. Product/service systems, like MaaS, are business models suited for the circular economy as they influence companies to create more durable products and customers only pay when using a product. Main elements of MaaS are ticket and payment integration, mobility package and ICT integration. Moreover, the three transportation modes used in MaaS systems are micromobility, public transport and cars – via ride-sharing and -hailing. The implementation of MaaS schemes has challenging factors, like the different stakeholder perspectives and roles. Other challenges are the necessity of solid business models that include sustainable value capture. Finally, the COVID-19 pandemic could create a policy window that would accelerate the development of MaaS schemes worldwide.

Keywords: Mobility as a Service, characteristics, transportation modes, mobility, urban, innovation, integration.

Contents

Introduction

Initial predictions state that the demand for urban transportation is rising, resulting in an increase of noise disturbance, emissions, an overladen transportation network and road congestion (Sochor, Strömberg, & Karlsson, 2015). However, the current COVID-19 pandemic has drastically changed our travel behaviour, as lockdowns and travel restricting measures have been implemented. This creates a window of opportunity for de advancement of solutions for the transportation issues in urban areas.

Mobility as a Service (MaaS) is regarded as a hype that could pose as a solution. In recent years there has been a surge of shared (micro)mobility initiatives, such as bicycles, cars and e-mopeds. A survey amongst Dutch railway users showed that out of 1835 respondents, on average more than half has heard of but never used shared mobility modes. These shared mobility modes could enrich the trips of Dutch railway users (Wagner, 2020). However, as of now there is not a single integrated platform which enables a user to book a trip from door to door using different transportation modes.

MaaS systems are such integrated platforms that enable this new form of transportation. One of the earliest definitions of MaaS is "a system in which a comprehensive range of mobility services are provided to customers by mobility operators" (Heikkilä, 2014, p. 8). Later, Kamargianni and Goulding (2018, p. 1) defined MaaS as "[…] a user-centric, intelligent mobility distribution model in which all mobility service providers' offerings are aggregated by a sole mobility provider, the MaaS provider, and supplied to users through a single digital platform".

MaaS is one example of the emerging sharing economy in urban areas. It is part of a new business model trend that treats products as a services, where the usage of products is sold, rather the ownership of a product. These 'product/service systems' have been linked to the circular economy as it stimulates companies to create businesses in which the objective of the product is longevity and durability. This diminishes the stress on resources and motivates companies to develop into a circular business (Kjaer, Pigosso, Niero, Bech, & McAloone, 2018).

Through the reviewing academic literature on MaaS, this literature review focusses on the key characteristics of the concept, different transportation modes and the future of MaaS and its challenges. Academic articles on the topic of MaaS range from 2014–when the master thesis of Heikkilä introduced the concept amongst academia–up to as recent as July 2020 when Henscher wrote an article about the impact of the COVID-19 pandemic on the developments of MaaS.

Key characteristics

MaaS has been defined as a system in which different transportation modes are integrated, enabling users to plan a trip using different transportation modes, varying from shared micromobility to cars and public transport. As such, MaaS can be typified as a 'product/service-system; (PSS). Tukker (2015) describes PSS by making a distinction between three types. Firstly, the product-oriented PSS: a system in which additional services are added to the product sold. Secondly, the user-oriented PSS: a system which aims at selling the function of the product instead of the ownership.

Table 1. Core characteristics of MaaS as adapted from Jittrapirom et al. (2017).

Core characteristics	Description
1. Integration of transportation modes	MaaS systems integrate different transportation modes to stimulate the usage of public transport services. Users are encouraged to use public transport services to plan intermodal trips.
2. Payment option	There are two ways a MaaS scheme can offer payments. On the one hand pay-as-you-go, where a set price is payed to every provider of the transportation modes used in a trip. On the other hand, a monthly payment based on a quantifiable amount. This could be the number of kilometres, minutes or points.
3. One platform	The functionality of planning intermodal trips is offered in a platform that could be a web page or application for phones. This one centralized platform gives access to all services. Basic services include trip planning and booking, payment and information on departure times. Additional services could be integrations for weather forecasting and calendar applications.
4. Multiple actors	Different actors are involved in MaaS schemes, being (a) users of the platform, (b) suppliers of the platform and (c) platform owners.
5. Technology	MaaS is heavily reliant on different technologies, such as the internet (of things), GPS, devices, payment systems and database management systems.
6. Demand orientation	MaaS is focused on providing the best possible system for the demand for intermodal transportation by users of the platform.
7. Registration	The system requires for registration of user profiles so that payment information is included, and service personalisation is possible.
8. Personalisation	The system enables the user to set preferences for trips. Also, the system allows for personalised offers based on the personal data of the user.
9. Customisation	Users of MaaS are able to customise the system and/or payment packages to their liking, by for example excluding one of more transportation modes.

Thirdly, the result-oriented PSS: which aims at selling results, meaning that there is no predetermined product sold. MaaS fits the user-oriented category of PSS systems according to Tukker, as a MaaS system aims at centralizing the shared usage of different transportation modes of a certain area in one system. Moreover, Kjaer et al. (2018) identify five different strategies for PSS, three of which are applicable to MaaS. Starting with operational support, MaaS providers have to support the system by ensuring that the system operates well. Furthermore, the MaaS providers have to take care of the maintenance of all transportation products that are offered. Also, the MaaS providers retain ownership of their products and thus market the sharing of resources amongst users of the MaaS system.

Hagiu and Wright (2015) have connected MaaS to 'multi-sided platforms' (MSP): platforms that serve as markets, where transactions are mediated between different customer groups.. The most notable characteristic of MSPs is the existence of network externalities. The direct network effect can be explained as an increase in users of a platform, resulting in a enhanced functioning of the platform. On the other hand, the indirect network effect can be defined as a rise of users on one side that as a result is beneficial to other sides of the platform. For MaaS the direct network effect exists because when more customers use a platform, the more providers of transport modes are inclined to improve the system leading to better utility of the platform as a whole. Furthermore, indirect network effects on MaaS platforms occur as well, as the increase in users on a platform will benefit the providers of transportation modes and platform owners.

The definitions of MaaS in the introduction have already touched upon several core characteristics of MaaS. Additionally, Kamargianni, Li, Matyas, and Schäfer (2016) define three main elements within MaaS platforms, being (a) ticket and payment integration, (b) mobility package and (c) ICT integration. Moreover, the characteristics described in table 1 are based on a literature review by Jittrapirom et al. (2017).

Winter, Cats, Martens, and van Arem (2020) carried out a stated choice experiment about transportation mode choice amongst a sample of the Dutch urban population. Research that in this sample there are roughly three user classes to be distinguished for the use of shared transportation modes and car-sharing services. Firstly, "Brisk Sharers" (62,9%) have a preference for shared transportation modes over private cars. Secondly, "Public Transport Enthusiasts" (20,3%) are public transport commuters and do not use private cars. Thirdly, the smallest group, "Car Captives" (16,8%) which commute by private car and are not inclined to use other shared transport modes. Table 2 shows that higher educated and younger respondents are more attracted to using shared transportation modes and car-sharing services (Winter et al., 2020).

Transport modes

Cars

Urban traffic congestion is caused by several developments since the early 1990s. Firstly, the increased economic welfare lead to cars becoming accessible for the middle-income class.

Table 2. Class membership probability per socio-economic value (Winter et al., 2020).

Socio-economic variable	Sample average	"Brisk Sharers" (62,9%)	"Public Transport Enthusiasts" (20,3%)	"Car Captives" (16,8%)
18 to 39 years old	47%	57%	33%	25%
High educational level	47%	50%	44%	37%
Commute by private car (and not by public transport)	37%	35%	6%	81%
Commute by public transport (and not private car)	25%	22%	53%	4%

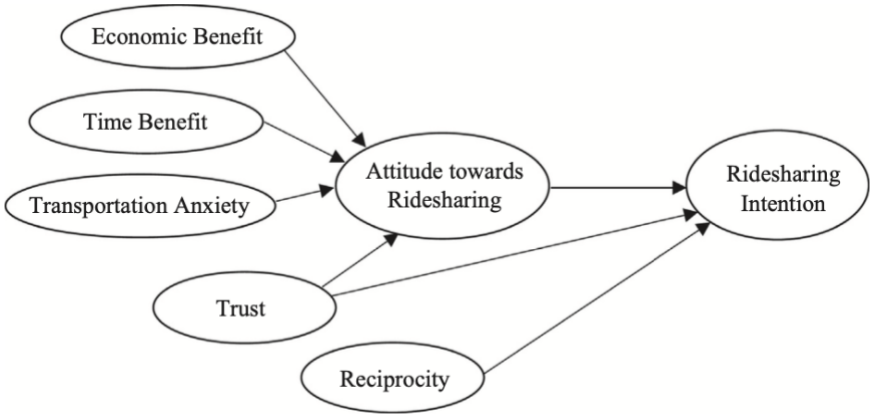

Figure 1. Ride-sharing motives model (Amirkiaee & Evangelopoulos, 2018).

Moreover, urban traffic congestion was furthered by depreciating retail prices, growing population, diminishing household sizes, more accessible credit and lacking urban transport policy (Thomson & Bull, 2002). There is a need for new transportation solutions as a result of the increase in urban traffic volumes along with the need to decrease greenhouse gas emissions, in combination with the growing array of mobility needs.

MaaS is one of the proposed solutions for this problem. The role of cars is predicted to change in the coming years, as with MaaS, households no longer need to have a private car available. The indirect network effect of a MaaS platform would benefit of the decrease in privately owned and used cars, as more households will be using the MaaS platform and which would benefit the utility of the platform as a whole. Moreover, by integrating various ride-sharing and ride-hailing services within a MaaS platform, the convenience of private car transportation can be preserved without the implications of owning a car. The role of cars in urban transportation will change when MaaS platforms are implemented. As previously described, cars on the road will no longer be privately owned cars as they will be used for ride-sharing and ride-hailing. Additionally, the reduction of the need for parking space offers different possibilities for land use. This is a positive change, as land shortage in urban areas is common and the reduction of parking space gives way for other usages of the land (Utriainen & Pöllänen, 2018).

Ride-sharing has emerged in recent years as a result of decreased economic

welfare and an increase in use of mobile technologies (Amirkiaee & Evangelopoulos, 2018). This phenomenon has been referred to as the 'uberisation' of the transportation in urban areas (Mulley & Kronsell, 2018). Amirkiaee and Evangelopoulos (2018) researched motives for the usage of ride-sharing options. Their findings, as illustrated in figure 1, point out that the attitude towards ride-sharing was determined by economic and time benefit, transportation anxiety, and trust. However, the intent to participate in ride-sharing is determined by factors such as reciprocity, trust and the attitude towards ride-sharing (Amirkiaee & Evangelopoulos, 2018).

Micromobility

The International Transport Forum (2020) defined micromobility as: "[...] the use of micro-vehicles: vehicles with a mass of no more than 350 kg (771 lb) and a design speed no higher than 45 km/h. This definition limits the vehicle's kinetic energy to 27 kJ, which is one hundred times less than the kinetic energy reached by a compact car at top speed.". Following this definition, different kinds of micromobility can be distinguished. Firstly, human-powered micro-vehicles, such as but not limited to bicycles, velomobiles and scooters. Secondly, electronically powered micro-vehicles such as e-scooters, e-mopeds, e-bikes and e-microcars. These examples of micromobility can be used privately, however in recent years the shared usage of such micromobility has become a trend. The demand and supply of shared micromobility increased as a market emerged for the final travelling distance between public transportation and the users' front door. This also increases the access to public transport by making it more appealing. The rise of micromobility contributes to the changing mobility behaviours and patterns and as an effect, there is less need for private cars in urban areas (Oeschger, Carroll, & Caulfield, 2020).

Public transport

With the emergence of MaaS, the role of public transport continues to shift. For long, public transport has been the alternative to using private transportation modes. However, since the implementation of shared mobility alternatives the public transport has competition within the domain of non-private transportation modes. A disadvantage of public transport is that it does not provide door to door trips, a gap that shared (micro)mobility responded to. This means that the role of public transport will change with the introduction of MaaS. It does not merely introduce opportunities to attract more travellers to public transport, it also makes private-public partnerships more necessary (Smith, Sochor, & Karlssona, 2017).

Future of MaaS

Challenges

In order for MaaS to be implemented in the future, it is necessary to create prototype business models for MaaS. In MaaS systems, private and public actors are at play. Polydoropoulou et al. (2020) studied various business perspectives of MaaS in three urban areas: Budapest, the city of Luxembourg and Greater Manchester. The key actors in these urban areas were local and/or regional public authorities and mobility providers such as public transport operators. Without a full cooperation of these actors, it is impossible to create a functioning MaaS system. Furthermore, it seems that public transport operators are best suited to be the platform operators of

MaaS on account of their well-established place in the urban mobility network. However, a contradiction arises as public transport operators are not in the position to undertake this role, as there is a lack of structure and resources. Additionally, when a public transport provider operates the MaaS system, regulatory barriers such as the prohibiting of using commercial tactics could make the system operator role impossible (Polydoropoulou et al., 2020).

Another challenge that MaaS schemes face is capturing sustainable value in their business model. Sustainable value capture is arduous on account of its nature as a merit good. Sarasini, Sochor, and Arby (2017) argue that "the consumption of a merit good generates positive externalities (or less bad negative externalities) that are greater than private benefits perceived the individual consuming the good".

Moreover, the transport modelling at the demand- and supply-side pose challenges to the implementation of MaaS. At the demand side, the European Commission (2016) underlined the underdevelopment of studies on the impacts of MaaS on travel behaviour. At the supply side, many challenges lay ahead in the field of integrating all different transportation modes ranging from free-floating car-sharing to on demand carpooling (Jittrapirom et al., 2017).

In order for MaaS schemes to be the solution to urban transportation issues it is essential that private and public actors work together closely, bearing in mind the different perspectives. Also, business models need to be developed to set out all of the challenges that are inherent to MaaS systems.

Impact of COVID-19 on development

In the beginning of 2020 the COVID-19 virus was introduced to the world and later became the COVID-19 pandemic. Hensher (2020) illustrated two possible scenarios for the development of MaaS after the pandemic. The first scenario is a return to the situation before the pandemic within a few months, where the usage of private cars, public transport and shared mobility would have the same levels of usage. Another scenario is the acceleration of MaaS developments. Because of the airborne COVID-19 virus, measures to dam the virus amongst others were working from home. The situation in which large parts of the working population are working from home is unprecedented. Now, the pressure that commuters exert on the urban transportation network can be compared to the pressure they used to exert before the pandemic measure of working from home was implanted. This shows that road congestion and crowded public transport can be prevented by working from home or by working different hours. Therefore, the need for private cars diminishes, which is an opportunity for MaaS to present itself as a good alternative.

Discussion

This literature review is limited in the number of topics of MaaS that are addressed. However, this literature review captures the essential knowledge for the understanding of the MaaS topic and could be a starting point for other academic writings on the more technical aspects of MaaS.

Conclusion

The aim of this literature study was to give a synopsis of the current academic literature on MaaS. MaaS is a possible solution for emerging problems in urban areas of road congestion, gas emissions and the growing array of mobility needs. The first topic discussed was key characteristics of the concept. MaaS can be typefied as a user-oriented PSS–with the aim to sell the function of the product instead of the ownership–and an MSP–where (in)direct network effects influence the quality of the platform for users and the benefit for the providers of transportation modes. Moreover, the three main elements of any MaaS scheme are (a) ticket and payment integration, (b) mobility package and (c) ICT integration.

The three transportation modes within a MaaS system are cars, micro mobility and public transport. The role of cars will change drastically as the majority part of cars will no longer be privately owned, as they will be used for ride-sharing and ride-hailing. The reduction in private cars will lead to a decrease in parking space, freeing up land that can be used another way. Micromobility exists in many forms, for example human-powered bicycles or electricity-powered scooters and mopeds. They create a solution–where public transport is lacking–for the first and last distance of any door-to-door trip. MaaS systems will require a change in the public transport system, as more private-public partnerships are necessary.

There are multiple challenges that MaaS must face in the years to come, most important of which the change in roles for various stakeholders. Moreover, appropriate business models must be designed in order to enable sustainable value capture. Finally, the COVID-19 pandemic could create two scenarios for the development of MaaS. The situation could return to the previous state–however, the lockdown-imposed working from home creates a window of opportunity that could accelerate the implementation of MaaS platform worldwide.

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Appendix A. Annotated overview of literature

#	Source	Type of source	Summary	Relevant information	CRAAP score
1	European Commission (2016)	Electronic book section	Horizon 2020 is a work programme for 2016-2017 for Transportation Research which explains the plans of the European Commission for those years.	There is an underdevelopment of studies on the impacts of MaaS on travel behaviour (p.51).	81
2	Hagiu and Wright (2015)	Journal article	Research into economic trade-offs that arise when companies move closer to or further away from a multi-sided platform business model	Direct network effects are a rise in the functionality of the platform by an increase in users. Indirect network effects are an increasing benefit for the providers in a platform when users increase (p. 163).	77
3	Heikkilä (2014)	Thesis	Research into the way Helsinki responds to trends in mobility such as MaaS.	"Mobility as a Service (MaaS) is a system, in which a comprehensive range of mobility ser- vices are provided to customers by mobility operators" (p. 8).	58
4	Hensher (2020)	Journal article	Possible scenarios of mobility in urban areas post COVID-19 pandemic.	Scenario 1: mobility will not change after pandemic (p. 551). Scenario 2: working from home (pandemic measures) creates a policy window for the development of MaaS (p. 552).	36
5	International Transport Forum (2020)	Report	Research in to the traffic safety of different micromobility alternatives.	Micromobility is "[...] the use of micro-vehicles: vehicles with a mass of no more than 350 kg (771 lb) and a design speed no higher than 45 km/h. This definition limits the vehicle's kinetic energy to 27 kJ, which is one hundred times less than the kinetic energy reached by a compact car at top speed." (p. 14).	52

#	Source	Type of source	Summary	Relevant information	CRAAP score
6	Jittrapirom et al. (2017)	Journal article	Literature into MaaS focussed on the business model and transport modelling.	Key characteristics of MaaS (p. 17). New on-demand mobility services will need to be integrated into the MaaS systems, which is difficult as they all function differently (p. 20).	89
7	Kamargianni and Goulding (2018)	Conference proceedings	Development of a MaaS maturity index which shows whether a city is ready for implementation of MaaS.	Mobility as a Service can be defined as "[…] a user-centric, intelligent mobility distribution model in which all mobility service providers' offerings are aggregated by a sole mobility provider, the MaaS provider, and supplied to users through a single digital platform" (p. 1).	76
8	Kamargianni, Li, Matyas and Schäfer (2016)	Journal article	New mobility services are reviewed and the development of an index for integration in MaaS of those mobility services.	Main element of MaaS: ticket and payment integration, mobility package and ICT integration (p. 3295).	84
9	Kjaer, Pigosso, Niero, Bech and McAloone (2018)	Journal article	Two-step framework to establish whether a product/service system is capable of absolute resource decoupling.	Product/service systems are linked to the circular economy, as they motivate long product life (p. 23).	78
10	Mulley and Kronsell (2018)	Journal article	Evidence from workshop about the 'uberisation' of public transport and MaaS.	'Uberisation' is the introduction of new mobility services or another word for MaaS (p. 568).	51
11	Oeschger, Carroll and Caulfield (2020)	Journal article	Literature review on the integration of micromobility and public transport	Different forms of micromobility (p. 1).	73
12	Polydoropoulou, Pagoni, Tsirimpa, Roumboutsos, Kamargianni and Tsouros	Journal article	Prototype business models for MaaS systems in Greater Manchester, Budapest and the city of Luxembourg.	The role of public transport in MaaS schemes is challenging, as it would be the most suitable as platform operator. However, the public transport providers are not equipped to take on this role (p. 160).	86

#	Source	Type of source	Summary	Relevant information	CRAAP score
13	Sarasini, Sochor and Arby (2017)	Journal article	Examination of different ways in which MaaS business models can capture sustainable value.	Sustainable value capture is challenging as it is a merit good (p. 5).	68
14	Smith, Sochor and Karlssona (2017)	Journal article	Study into the implications of MaaS for traditional public transport.	Implementation of MaaS puts pressure on private-public relationships (p. 2).	67
15	Sochor, Strömberg and Karlsson (2015)	Journal article	Study into the different challenges of integrating different perspectives in MaaS.	Consequences of the rising demand for transportation are increasing emissions, overcrowded infrastructures, congestion and noise disturbance (p. 1).	62
16	Thomson and Bull (2002)	Journal article	The social and economic causes and consequences of urban traffic and congestion.	Increased economic welfare, depreciated retail prices, a growing population, diminishing household sizes, accessible credit and a lack of solid urban transport policy are causes for urban congestion (p. 107).	84
17	Tukker (2015)	Journal article	A literature review on product/service systems and their influence on creating a circular economy.	The distinction of three different types of product/service systems: product-oriented, user-oriented and result-oriented (p. 81).	73
18	Utriainen and Pöllänen (2018)	Journal article	Literature review on the current state of MaaS research and future research suggestions.	New solutions for transport are necessary, on account of increasing amounts of traffic and the problem of increasing emissions (p. 15).	89
19	Wagner	Web page	Research results on research into awareness about shared bicycles, e-scooter and cars in the Netherlands.	Results show that most respondents are aware, but have not used the micromobility services.	55
20	Winter, Cats, Martens and van Arem (2020)	Journal article	Stated-choice experiment to identify different user classes for shared and automated mobility services.	There are roughly three user classes: “Brisk Sharers”, “Public Transport Enthusiasts” and “Car Captives” (p. 5-7).	87

Appendix B. Expert opinion Carlo van Gilst

Carlo van Gilst is thesis intern at LeasePlan and focused on optimizing the new shared vehicle service of LeasePlan. His expert opinion on MaaS is the following:

"I think that MaaS has great potential to change the current transportation network within large cities. However, it will take some time before smaller cities and rural areas can benefit from the MaaS systems. Eventually the dream situation would be that a small country like the Netherlands has one MaaS platform for all of the large cities and urban areas. The rise of autonomous vehicles is a trend that will make it possible to develop even more flexible MaaS systems. Autonomous vehicle usage in MaaS systems will increase the functionality of such platform, leading to more users. This is de indirect network effect as you explain in your literature review as more users of a platform will increase the functionality. Finally, it is mostly big mobility companies that are the ones that have to partner up with public actors, like municipalities, to make the MaaS systems happen and to make fast scalability possible" (van Gilst, 2020).

Appendix C. Expert opinion Tom Hoobroeckx

Tom Hoobroeckx is thesis intern at felyx, a shared e-scooter company in Europe where he is focused on implementing dynamic pricing. His expert opinion on MaaS is the following:

"The introduction of micromobility transport modes has created the opportunity for the transport system to move from traditional transportation modes – like cars and public transport – to a broader urban mobility system. Firstly, it has made it easier for travellers to avoid congestion during peak hours. Secondly, the convenience of door to door and last mile transport is enabled by companies like felyx. Also, the customers only pay for the usage and not for maintenance or ownership. This is in line with the concept of Mobility as a Service. One of critical notes is that the introduction of e-micromobility has decreased the share of active modes (e.g., walking and cycling). Due to this trend, the sustainability aspect of the solutions can be considered less sustainable, as it does not only replace (polluting) transportation by car. Additionally, the shift to micromobility has accelerated because of the demand for private shared mobility like felyx. This could be explained by the impact the COVID-19 pandemic has on our travel behaviour. Furthermore, the integration of micromobility provider into MaaS like schemes should be improved, as a fully functional platform does not exist yet. A fully integrated MaaS scheme could be a real opportunity for felyx, as most of the usage of felyx mopeds is for leisure. When employers provide their employees with mobility packages for a MaaS scheme, in which felyx is integrated, the amount of business and commuting trips could increase " (Hoobroeckx, 2020).