



Review article

The Ws of MaaS: Understanding mobility as a service from a literature review

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ABSTRACT

Transport integration has evolved into Mobility as a service (MaaS), and as a recent topic, MaaS-literature is rapidly growing. This study analyses 57 MaaS-focused documents (the majority being peer-reviewed articles) from Scopus in January 2019. The aim is to comprehensively answer MaaS basic W-questions: 1) What is MaaS? 2), When and where did the term appear? 3), Who are the main actors in MaaS? 4), How can MaaS be implemented? and 5) Why should it be implemented? Future research lines are also offered. Our findings show that MaaS is an ongoing topical subject; there are still many contributions under development to reach a definition. In order to succeed in implementing it, key stakeholders, such as transport authorities and transport operators, must cooperate to achieve the predicted sustainable effects envisioned. New data on user travel behaviour and their preferences should be obtained through MaaS pilots, helping transport planners and policy makers when evaluating MaaS impacts and its feasibility to be the next transport paradigm.

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1. Introduction

Under the framework of smart cities, the sharing economy has emerged as a strategy to achieve more sustainable consumption [1],

prompting the servicizing era, which is beginning to blur the line between ownership and access by using and distributing underutilized assets [2]. In the transport arena, this translates into more than 60,000 travel apps currently available on Google Play [3]. Many of these applications are shared mobility services.

Shared mobility is defined as the short-term access to shared vehicles according to the user's needs and convenience, instead of requiring vehicle ownership [4]. These services are provided mainly, by private companies and they usually operate in central zones for short distances,

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being complementary with public transport. Shared mobility has expanded the panel of transport modes available besides car-sharing, with a more recent increase in bike-sharing, moto-sharing and scooter-sharing [5].

With options increasing, users find it difficult to navigate through all the information sources, applications, tickets and journey planners [6]. The need for a single, user-friendly platform that integrates all services has enabled the concept of Mobility as a Service (hereinafter, MaaS). MaaS promises to be the change in transport that occurred several years ago for the telecommunications sector with bundled services [7].

With the rise of this new concept, academic literature is rapidly growing. Hence, a bibliographic review that quickly introduces the topic to policy makers or transport planners may be of help. In this manner, some previous reviews on MaaS have appeared: Jittrapirom et al. [2], for example, have focused on a general overview of the term's definition, Kamargianni et al. [8] on trials and implementation requirements, and Mulley [7] on a brief recompilation of topics and challenges. Only a few studies are found that systematically analysed bibliography: Utraiainen and Pöllänen [9] selected 31 documents focusing on the roles of different transport modes in MaaS, Durand et al., [10] selected 14 documents and specifically analysed travel preferences and behaviour, whereas Wittstock and Teuteberg [11] selected 95 documents (37 scientific and 58 grey literature) and attempted to identify MaaS core elements.

Based on these previous reviews, we would like to develop a more holistic, quick-to-catch-up state of the art on MaaS. Our aim with this review is to break the MaaS topic down, to the extent possible, into the typical W-questions: 1) What is MaaS? 2) When and where did the term appear? 3) Who are the main actors in MaaS? 4) How can MaaS be implemented? and 5) Why should it be implemented and what effects could it bring? Answering these questions by systematically analysing others' findings may prove of interest to the Scientific Community. The rest is structured as follows: Section 2 describes the searching process used, Section 3 organizes findings according to the W questions, and Section 4 discusses key findings, conclusions and future research lines.

2. Search methods and a first glance at publications

The literature review is mainly composed of peer-reviewed journal articles and conference papers; however, it also includes some grey literature (institutional reports, master thesis, working papers and a book chapter) as the MaaS topic is relatively recent and we considered it necessary for addressing the topic from a general perspective. The first search was carried out in January 2019 through Scopus database. The exact keyword "Mobility as a service" was searched for English-written documents coming from Journals and conference proceedings databases. The whole string for the first search in Scopus was: KEY ({mobility as a service}) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "ch") OR LIMIT-TO (DOCTYPE, "re")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "p")), obtaining 39 documents.

Some documents were excluded because they were not fully MaaS-focused and discussed other topics (e.g., computer science topics, mobile networks, architecture, and the mathematics behind a mobility application, etc.). We kept 19 documents that addressed mobility issues, and from there we started "snowballing", which consisted of searching for references: one paper lead to another, and so on. In total, 57 documents were reviewed: 25 were journal articles, 14 were conference papers, 10 were institutional reports, five were master theses, two were working papers and one was a book chapter (see Table 1).

In Table 1, we have classified the 57 MaaS documents into two main types according to the type of evidence they are based on: 1) conceptual, and 2) empirical. Conceptual studies are based on general theoretical frameworks, regulation/governance backgrounds, definition

approaches, classification schemes, implementation issues, theory models and different scopes of MaaS. While empirical studies are based on real evidence from MaaS pilots, meaning studies that addressed MaaS' users' preferences, travel behaviour or different analysis by conducting an experiment. Most of the documents are conceptual with 35 documents and 22 being empirical.

Maas is a topical subject, as the publishing time of documents support. Only two documents were published in 2014, as opposed to 23 in 2018, which clearly supports that MaaS-literature grew from 2016 as seen in Fig. 1. Additionally, based on the first writer's affiliation, MaaS literature continues to have a strong base in Europe (51 publications). The United Kingdom, Sweden and Finland are the countries with the most publications (15, 13 and 8, respectively). This is related to the fact that most initiatives on MaaS are progressing mainly in the European Union, especially by the European Commission through its ITS Action Plan formulated in 2008 [12].

3. The "what" of MaaS: towards a definition of mobility as a service

One of the first definitions of MaaS was offered by Sonja Heikkilä as "a system in which a comprehensive range of mobility services are provided to customers by mobility operators" [13]. In 2014, Hietanen [14] described Maas as a distribution model that delivers users' transport needs through one single interface of a service provider, combining different transport modes to offer tailored mobility packages. The "mobility package" idea is based on an analogy to the telecommunication sector with the introduction of mobile phone contracts in the 90's [14]. Another very frequent definition found in literature is provided by MaaS Alliance, as the integration of various forms of transport services into one single mobility service accessible on demand [15]. Sakai [12] broadly considers MaaS as all the modes of transport other than private cars. In general, when defining MaaS, the different authors attempted to highlight its core elements: a unique single platform (app or website), real-time information on all available modes in the city (public and private), multimodal transportation (intermodal journey planners), technological integration to plan, book and pay for mobility needs, and personalized bundled mobility packages according to user's particular requirements [16]. In a broad sense, MaaS requires the integration of different aspects, ranging from the initial integration of information, booking and payment functions up until the bundling of services and the development of general policies [71].

Another important core element identified by authors is MaaS' user-centric approach, as tailored mobility packages are outlined as important, completely personalizing the user's particular travel needs [17,18]. Other authors support that it is a shift of paradigm because MaaS will be an on-demand service that would incorporate all transport modes from electric scooters, bikes, cars or motorcycles (shared mobility) to the bus, metro, tram, rail, or even flights (as enthusiastic as this may sound) [19–21]. Instead of owning individual modes of transportation, customers will purchase mobility service packages or simply pay per trip [22].

Having a centralised management in a single application may enable operators to improve the service with precise knowledge of the user's travel preferences and travel behaviour [23]. Moreover, this one-stop-shop principle could promote intermodal trips while avoiding the hassle of having to check multiple information sources, journey planners and ticketing applications [24–26].

From an organisational perspective, MaaS is intended to be an ecosystem that should integrate public and private operators with a MaaS Provider in the middle, managing both demand and supply by offering mobility services to end users, as well as dispatching/assigning daily trips to several operators [27]. Intermodal trips made within MaaS could be complementary; public transport for dense areas, and private shared mobility for last mile [28].

Table 1

MaaS-focus documents ordered by published date.

#	Author(s)	Origin ^a	Evidence	Objective	Findings
1	(Heikkilä, 2014)	Finland	Conceptual	Identify the main factors that are enabling MaaS and propose a road map for the case of Helsinki.	Factors enabling MaaS include: social change, urbanization and globalization, servicing and sharing, scarcity of resources, technological advances and paradigm change.
2	(Sochor, Strömberg, & Karlsson, 2014)	Sweden	Empirical	Discuss insights from the UbiGo pilot regarding motivations and deterrents for adopting MaaS.	78.8% said they would be interested in becoming a UbiGo customer, 18.1% said yes but under certain conditions, and 3.1% said no.
3	(Rantasila, 2015)	Finland	Conceptual	Study the impact of MaaS in land planning.	Two scales of MaaS impact: macro as a new transport paradigm and micro as operational regulations and new legislation will be needed.
4	(Sochor et al., 2015b)	Sweden	Empirical	Explore how user, commercial and societal expectations are met when using MaaS.	Differences appear in how the reduction of car use is estimated and the proposition of various business models and MaaS platforms.
5	(Sochor et al., 2015a)	Sweden	Empirical	To discuss changes in users' travel behaviour and mode choice.	Differences in travel behaviour allowed the identification of four type of users: shedders, keepers, car-sharing and car accessors. In general, all four groups shifted to a more sustainable mobility patterns after the pilot.
6	(Kamargianni et al., 2015)	UK	Conceptual	Conduct a feasibility study for MaaS in London.	MaaS for London was proved feasible for having: public transport as backbone, ICT integration for information and payment, one single platform, cooperation between different stakeholders and tailored packages.
7	(Holmberg et al., 2016)	Sweden	Conceptual	Create a comprehensive framework to understand MaaS concept.	Identified barriers for MaaS include: public transport subsidizing, brand-exposure of transport operators, regulation issues and technical matureness.
8	(Kamau et al., 2016)	Japan	Conceptual	Introduce a MaaS model.	The MaaS research pilot decreased waiting time by 25% compared to current public transport in Dhaka.
9	(Giesecke et al., 2016)	Finland	Conceptual	Identify key aspects for consideration when implementing MaaS.	Introduced the sustainable perspective of MaaS by identifying four main components to be consider: 1) the nature of travel, 2) interoperability, 3) end-user perspective and 4) sustainability.
10	(Sochor et al., 2016)	Sweden	Empirical	Discuss UbiGo results and describe changes in users' travel behaviour and mode choice.	All participants reduced automobile usage. Factors influencing travel choices include: cost, convenience, discovery/rediscovery of other modes and personal reflection.
11	(Karlsson et al., 2016)	Sweden	Empirical	Analyse barriers that can be found within the service itself, focusing on stakeholders' rather than users' willingness for joining MaaS, which could be as important.	Stakeholder's cooperation is needed for issues regarding infrastructure, information, and payment systems but also in <i>service-related</i> issues like the lack of trust between them, unequal distribution of power and resources, differences in goals, larger political commitment and regulatory context.
12	(Kamargianni et al., 2016)	UK	Empirical	Review the existing MaaS schemes and develop an index to evaluate their level of mobility integration.	A MaaS index is proposed and applied: only one (Whim) out of the 15 schemes analysed, has total integration, 8 have intermediate integration and 6 have basic integration.
13	(Datson, 2016)	UK	Conceptual	Explore the opportunity MaaS offers UK.	Focus on a brief conceptual introduction to MaaS and the future role of transport policy and possible market growth scenarios.
14	(Nemtanu et al., 2016)	Romania	Conceptual	Introduce a MaaS model.	The model has 2 components: users and MaaS providers. The platform has 8 functions: profile builder, security, transport offers, negotiation, financial, trip planning, urban conditions and the interface.
15	(Ambrosino et al., 2016)	Italy	Conceptual	Introduce a MaaS model.	From a MaaS business model perspective, the authors identified B2A (administration), B2B (companies) and B2C (users) services that MaaS can offer to be sustainable.
16	(König et al., 2016)	Belgium	Conceptual	Identify sustainable business models for MaaS.	Two revenue sources were identified: agency (reselling) and merchant (commission). Four business models are proposed: resellers, providers, public transport operators or public-private partnerships (PPP). The latter is the most recommended (PPP).
17	(Sochor, Arby, Karlsson, & Sarasini, 2017)	Sweden	Conceptual	Develop a topological approach for MaaS concept.	Proposed topology include integration levels: 0 no integration; 1 information; 2 booking and payment; 3 service offer, including contracts and responsibilities and 4 societal goals.
18	(Aapaoja et al., 2017)	Finland	Conceptual	Identify MaaS combinations for urban, suburban, rural and national/international areas.	Each area has different objectives and services combinations. In the short run, urban areas are most fitted for MaaS with the aim of reducing congestions with public transport and shared mobility services.
19	(Jittrapirom et al., 2017)	The Netherlands	Conceptual	Identify MaaS core characteristics and review existing schemes.	12 MaaS schemes are reviewed. Core characteristics include: integration of transport modes, tariff option, one platform, multiple actors, use of technologies, demand orientation, registration requirement, personalisation and customisation.
20	(Mulley, 2017)	N/A	Conceptual	To broadly introduce the hype around the MaaS topic.	MaaS definition is offered as well as Australia's approach to enabling MaaS.

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Table 1 (continued)

#	Author(s)	Origin ^a	Evidence	Objective	Findings
21	(Ratilainen, 2017)	The Netherlands	Empirical	Explore users' preferences towards 10 designed mobility packages.	Unlimited public transport makes bundles more attractive, elderly people were found interested if offered discounts on off-peak hours. Young were eager for MaaS but they are pretty price-sensitive.
22	(Sarasini et al., 2017)	Finland	Conceptual	Evaluate sustainable MaaS business models.	Potential mechanisms for value capture include: bundling (buying mass volume to a cheaper price), selling MaaS data analytics, fees in transactions and advertising.
23	(Nikitak et al., 2017)	UK	Conceptual	Explore the new mobility initiatives.	Legislation improvements and cooperation will be as important as technical issues for enabling MaaS.
24	(Haahela et al., 2017)	Finland	Empirical	Explore MaaS and commuting trips in Finland.	Only 6% of respondents actually work when commuting, whereas most of them use their phone for leisure (27%), reading (12%) and calling (11%). Nearly 80% combine shopping with commuting. Car-owners demand deliver-pick up for children as a motivation to join MaaS.
25	(Goodall, Dovey Fishman, Bornstein, & Bonthron, 2017)	N/A	Conceptual	Describe the MaaS concept and main topics related in a broad manner.	MaaS definition is offered, ecosystem, drivers, pilots and policy issues broadly described.
26	(Gaudó Labarta, 2017)	Spain	Conceptual	Conduct a feasibility study for MaaS in Barcelona.	MaaS (1.188 euros/year) was proved to be cheaper than automobile ownership (6.810 euros/year). MaaS demand in Barcelona was estimated around 43,000 users, of which about 14,000 would come from private transport.
27	(Hensher, 2017)	Australia	Conceptual	Explore considerations regarding bus contracts in a MaaS context.	A hybrid multi-modal scenario is recommended. The author introduces the three Bs approach of MaaS: bundles, budgets and brokers.
28	(Johansson, 2017)	Sweden	Empirical	Explore young people's mobility demands for MaaS.	Mobility preferences are strongly influenced by parents and the reverse is also true. They are aware of environmental issues, but the sustainable option needs to also be price-convenient.
29	(Li et al., 2017)	Belgium	Conceptual	Identify MaaS core elements and implementation issues.	Pre-conditions for MaaS include: wide range of transport modes, transport operator's open data and allowing other to sell service and e-payment availability. New targets of MaaS are introduced: elderly and tourists. Tax policy and fair competition issues are important.
30	(Kamargianni et al., 2017)	UK	Conceptual	Identify MaaS ecosystem.	MaaS ecosystem composed of: transport operators, data providers, technical backend and IT providers, ICT infrastructure, insurance companies, regulatory organisations, universities and research institutions and customers.
31	(Kamargianni & Goulding, 2018)	UK	Empirical	Measure cities' readiness for MaaS implementation.	MaaS maturity index is created. It considers: transport operator's openness and data sharing, citizen's familiarity and willingness, policy, transport services and ICT infrastructure.
32	(Matyas & Kamargianni, 2018c)	UK	Empirical	Explore how MaaS can serve as a mobility management tool to promote currently underutilized modes.	64% of respondents indicated they will start using the shared modes, 12% would definitely use them, demonstrating MaaS bundles could change travel behaviour towards an increase of sustainable modes.
33	(Kamargianni, Matyas, Li, & Muscat, 2018)	UK	Empirical	Explore citizens' attitudes towards owning and using a car in London.	59% think owning a car is a hassle. 18% stated that they would not buy a car in the future. 36% of non-car-owners stated they will delay purchasing a car. 14% of public transport users stated they would use more bike sharing. 35% of regular car users stated they will shift to public transport, 17% with bicycle and 17% with walking.
34	(Kamargianni, Matyas, Li, Muscat, et al., 2018)	UK	Conceptual	Create a MaaS dictionary.	Concepts around MaaS are gathered in a single document.
35	(Matyas, 2018)	UK	Empirical	Explore barriers for trying out new modes in a MaaS scheme.	Respondents classify the modes into 3 categories: essential (mainly public transport), considered (mainly car and bike sharing) and excluded. Barriers relate to safety, special needs (children seats and pet-friendly), hard access to vehicles and bad experiences.
36	(Matyas & Kamargianni, 2018a)	UK	Empirical	Explore users' preferences for MaaS plans.	Public transport was the most important mode for users (backbone of MaaS), regardless of socio-demographic variables. When choosing plans, habits and travel patterns play a key role (people select modes according to their experience with them). Bike and car sharing were less selected due to still lacking facilities.
37	(Matyas & Kamargianni, 2018b)	UK	Conceptual	Offer a methodological guideline for stated preferences surveys regarding MaaS.	Guidelines offered.
38	(Kriukelyte, 2018)	Sweden	Conceptual	Investigate the process of the institutionalization of MaaS in Stockholm.	Process involve: explaining MaaS drivers, the emergence of new challenges and the impact of MaaS in public organisations. Challenges ahead: ticketing, lack of pilots, and physical and technical infrastructure.
39	(Robinson, 2018)	Belgium	Empirical	Exploring MaaS users' preferences.	Eight user profiles were identified. The author highlights the importance of studying users' preferences to achieve attractive mobility bundles (importance of

Table 1 (continued)

#	Author(s)	Origin ^a	Evidence	Objective	Findings
40	(Utriainen & Pöllänen, 2018)	Finland	Conceptual	Review on MaaS scientific publications.	segmentation). Publications are mainly from Europe and North America. They amount of papers rapidly grew from 2016.
41	(Ho et al., 2018)	Australia	Empirical	Identify MaaS users' preferences for mobility packages.	Sydney travellers are willing to pay \$6.40 for an hour of car-sharing (one-way preferred over station-based schemes), and \$5.90 per day for unlimited public transport (which is much lower than the current daily cap).
42	(Strömberg et al., 2018)	Sweden	Empirical	Identify MaaS potential users.	Four profiles are identified: car shedders, car accessors, simplifiers, and economizers. The transport smorgasbord concept being a continued reminder of travel options was acting as a transport campaign, helping users to think deeply about their travel patterns.
43	(Stopka, Pessier, & Gunther, 2018)	Germany	Empirical	Identify the price users are willing to pay for joining MaaS.	People without a fixed income prefer mobility services that are charged according to the pay-as-you-go principle. The accepted price corridor is between 85 and 100 euros.
44	(Melis et al., 2018)	Italy	Conceptual	Introduce a MaaS model.	Highlights the importance to broaden MaaS targets, designing a model for tourists and blind people.
45	(Smith et al., 2018)	Sweden	Conceptual	Explore possible organisation schemes for MaaS.	Three scenarios are identified: market-driven (all private), public-controlled (all public) and public-private (mix). The mix approach is recommended. A model for MaaS is proposed.
46	(Kamargianni, Yfantis, et al., 2018)	UK	Conceptual	Propose an innovative integrated transport modelling and simulation framework for MaaS.	Agreed aspects: youth, current public transport users, and flexible travellers to be early adopters of MaaS. The implementation of MaaS as a pilot project is considered the most preferred policy in the next phase. Disagreed aspects: MaaS providers (if public or private) and implementation strategies.
47	(Jittrapirom et al., 2018b)	The Netherlands	Empirical	Identify which topics are experts agreeing and disagreeing on regarding MaaS.	Young to middle-aged people residing in urban areas are likely to be the first group to join MaaS. Users generally are price-sensitive.
48	(Durand et al., 2018)	The Netherlands	Conceptual	Review of MaaS documents that focused on people's travel preferences and behaviour.	United Kingdom's barriers are related to APIS availability while in Budapest are stakeholder's willingness for cooperation.
49	(Polydoropoulou, Pagoni, et al., 2018)	Greece	Empirical	Explore key stakeholders' preferences and opinions about MaaS.	They are willing to join. They propose public subsidy is given to users directly not operators, in order to be sustainable. They recommend specialized services in MaaS (for elderly and disabled).
50	(Mulley & Kronsell, 2018)	Australia	Empirical	Explore community transport organisations' willingness to join MaaS.	The DAP is recommended to plan for uncertain scenarios, like the MaaS context.
51	(Jittrapirom, Marchau, van der Heijden, & Meurs, 2018a)	The Netherlands	Conceptual	Propose Dynamic Adaptive Policymaking for MaaS implementation.	Main workshop topics are described.
52	(Mulley & Kronsell, 2018)	Australia	Conceptual	Summarize topics from a workshop about MaaS.	The SWOT is constructed and described.
53	(Eckhardt et al., 2018)	Finland	Conceptual	Construct a SWOT analysis regarding the implementation of MaaS in Finnish rural areas.	Core elements involve: unified platform, multimodality, user-centricity, cooperation, customisation and technology integration. Risk and opportunities regarding MaaS are also described.
54	(Wittstock & Teuteberg, 2019)	Germany	Conceptual	Identify MaaS core elements.	Private and public stakeholders seem to have embedded differences in their objectives being a barrier for them to collaborate.
55	(Smith et al., 2019)	Sweden	Conceptual	Analyse public-private cooperation for MaaS in Sweden.	The proposed taxonomy is: level 0 for no integration at all to level 5 for full operational, informational and transactional integration. A model for individual choice regarding the adoption of MaaS is proposed.
56	(Lyons et al., 2019)	UK	Conceptual	Propose a MaaS taxonomy and a model for implementation.	Barriers for adoption involve: inadequate integration with external transport systems; corporate policy, culture and norms that conflict with using the services; and system limitations due to laws and regulations.
57	(Hesselgren, Sjöman, & Pernestål, 2019)	Sweden	Empirical	Described findings from a corporate MaaS pilot.	

Source: author's own elaboration.

^a Origin = place of affiliation for the main author.

Considering all these aspects, and in agreement with the majority of authors, we will adopt the MaaS definition stated by Kamargianni and Goulding [29] as a user-centric, multimodal, sustainable and intelligent mobility management and distribution system, in which a MaaS Provider brings together offerings of multiple mobility service providers (public and private) and provides end-users access to them through a digital interface, allowing them to seamlessly plan and pay for mobility.

4. The “when” and “where” of MaaS: its recent, yet fast-growing history

MaaS has a recent nature. Sampo Hietanen claims to be the father of the concept as he proposed the mobility packages to the Finnish Transportation Ministry back in 2006 (see Fig. 2). [30]. Soon after, in 2009, the Finnish Ministry of Transportation and Communication published the

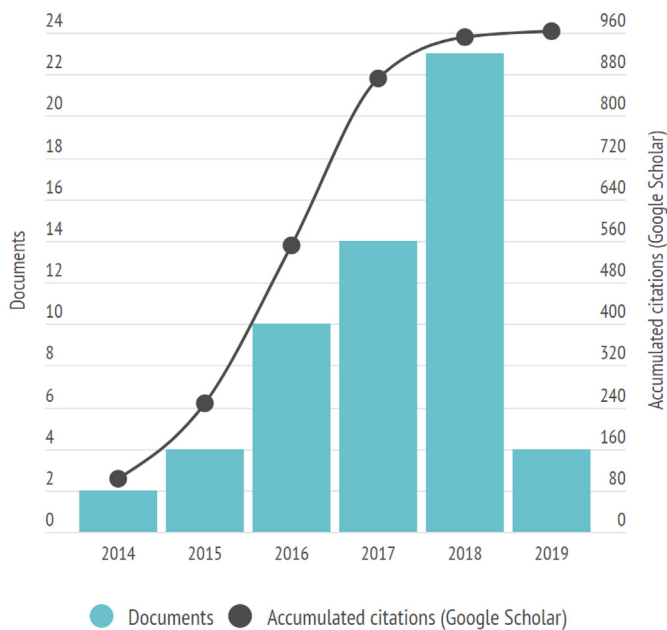


Fig. 1. Evolution of publication and citation of the 57 MaaS-documents.

first “Intelligent Transportation Strategy” and in 2010, all transport agencies were reformed. In 2011, a paper called “The Transport Revolution” was published by the Ministry, promoting what was known as *transport as a service*. By the end of 2013 (November), Sweden had developed the first MaaS-pilot called UbiGo, within the Go:Smart project [31]. Later in 2014, the notion of MaaS gained widespread publicity through the development of the “Helsinki Model” in Finland, proposed by Sonja Heikkilä in her master thesis, the first academic publication regarding MaaS [13].

In the literature reviewed, many authors have attributed authorship of the term to Sampo Hietanen as he spread the idea of mobility package and was one of Heikkilä’s instructors on her master thesis. He also launched, in 2014, the MaaS Global project to start the Whim app [32]. In 2016, a MaaS International Alliance was created to promote MaaS around the world. Until now, many MaaS pilots and studies have been developed, as tools for “learning by doing”, especially when the concept of MaaS is still recent and new evidence is required [33].

The most oft-mentioned MaaS pilots are UbiGo (Sweden-2013) and Whim (Finland-2016). Moreover, Kamargianni et al. [8] has identified 15 existing MaaS pilots around the world and has classified them according to their integration level: partial, advanced and advance with mobility packages. Kriukelyte [34] also complemented the list with 24 existing MaaS pilots, including those mentioned in Kamargianni et al. [8] with others in research phases. Some of the most important and frequently mentioned are:

- (1) MaaS pilots with partial integration: basic level of integration when a scheme not fully, but partially possesses ticketing, payment and ICT integration. Some pilots at this level of integration are: Moovel (Germany), Switchh (Hamburg, Germany), Qixxit (Germany), and Cambio-STIB (Belgium).
- (2) MaaS pilots with advanced integration: each pilot fully possesses ticketing, payment and ICT integration. Some pilots in this category are: Mobility Shop (Hannover, Germany), Smile (Vienna, Austria), Optymod (Lyon, France) and Open Mobility (Berlin, Germany).
- (3) MaaS pilots with advanced integration and mobility packages: they offer monthly packages and pay-as-you-go options for mobility. Some pilots in this category are: UbiGo (Gothenburg,

Sweden), and Whim app in Helsinki (Finland), Antwerp (Belgium), and West Midlands (UK).

However, out of all the existing MaaS pilots, we will highlight the findings from the two most oft-mentioned. Firstly, UbiGo app reported behavioural changes in mode choices, pre-trip planning, trip chaining, destinations and travel time in its trial version [21]. The most valuable finding was that it was acting as habit intervenor, and over time made them more conscious of the ‘smorgasbord’ of transport choices. On the other hand, Whim in Helsinki has also been operating since 2016. Its recent report states that 73% of its trips are being made with public transportation, as opposed to 48% of trips made by the average citizen [35]. They have also shown that 42% of all Whim users’ city bike trips are combined with public transportation, demonstrating that active modes are used for solving the last-mile problem [36].

5. The “who” of MaaS: stakeholders’ ecosystem

One recurring topic in literature is the identification of all actors involved in the service, known as the MaaS Ecosystem. This Ecosystem is the wider network of organisations that influences how a MaaS Provider creates and captures value [37]. Actors involved include transport operators, data providers, technology and platform providers, ICT infrastructure, insurance companies, regulatory organisations, universities and research institutions, and other media, marketing and advertising firms. Based on their interactions, value is captured, and benefits are obtained as seen in Fig. 3. Besides customers, which are the main reason for the service, transport authorities also play a key role according to reviewed authors, as they promote collaboration with different stakeholders [72]. They tend to have a societal focus, a dominant influence on public transport operators (as backbone), and the potential to enable MaaS through various policies and incentives [38].

All actors may have different interactions with the MaaS Provider. Transport operators will offer their service and data, and they will be able to expand their market due to more users being exposed to their mobility services. In the case of IT, ICT infrastructure, data, ticketing, and payment firms, they provide their cloud capacity, high speed connectivity, data analytics and single-payment solution services while opening a new market for new revenues. Companies that developed journey-planning applications are also needed, and must create multi-modal planners, promoting intermodality, while being easy-to-use and flexible for customisation. Unions are also considered, because they will most likely demand fair competition regulations in order to be open to MaaS. Universities and research institutes play a key role, as well, because they will develop knowledge based on pilots’ evidence in order to obtain tools and strategies for decision-making regarding MaaS. Finally, there are a few other actors, like insurance companies that may find new business possibilities [37]. Entertainment-related companies may also be interested in offering subscription packages for free Wi-Fi access while travelling, free access to newspapers and magazines, movies, music and gaming services, and even discounts to coffeehouses and restaurants to buy food for the trip, especially in the self-driving vehicle era, as it is expected that travellers would have freed time while not driving [39].

6. To whom is MaaS oriented?

Users are the main actors in the MaaS ecosystem, so market segmentation to target specific kinds of users with tailored mobility packages is one of the main challenges in research. In order to collect more data on their preferences and travel behaviour, recent MaaS pilots have been oriented towards offering collaborative, customised platforms. These platforms allow users to provide a great deal of detailed information on their profile and journeys, so that the mobility package offered can adapt as much as possible [40]. For other industries and businesses,

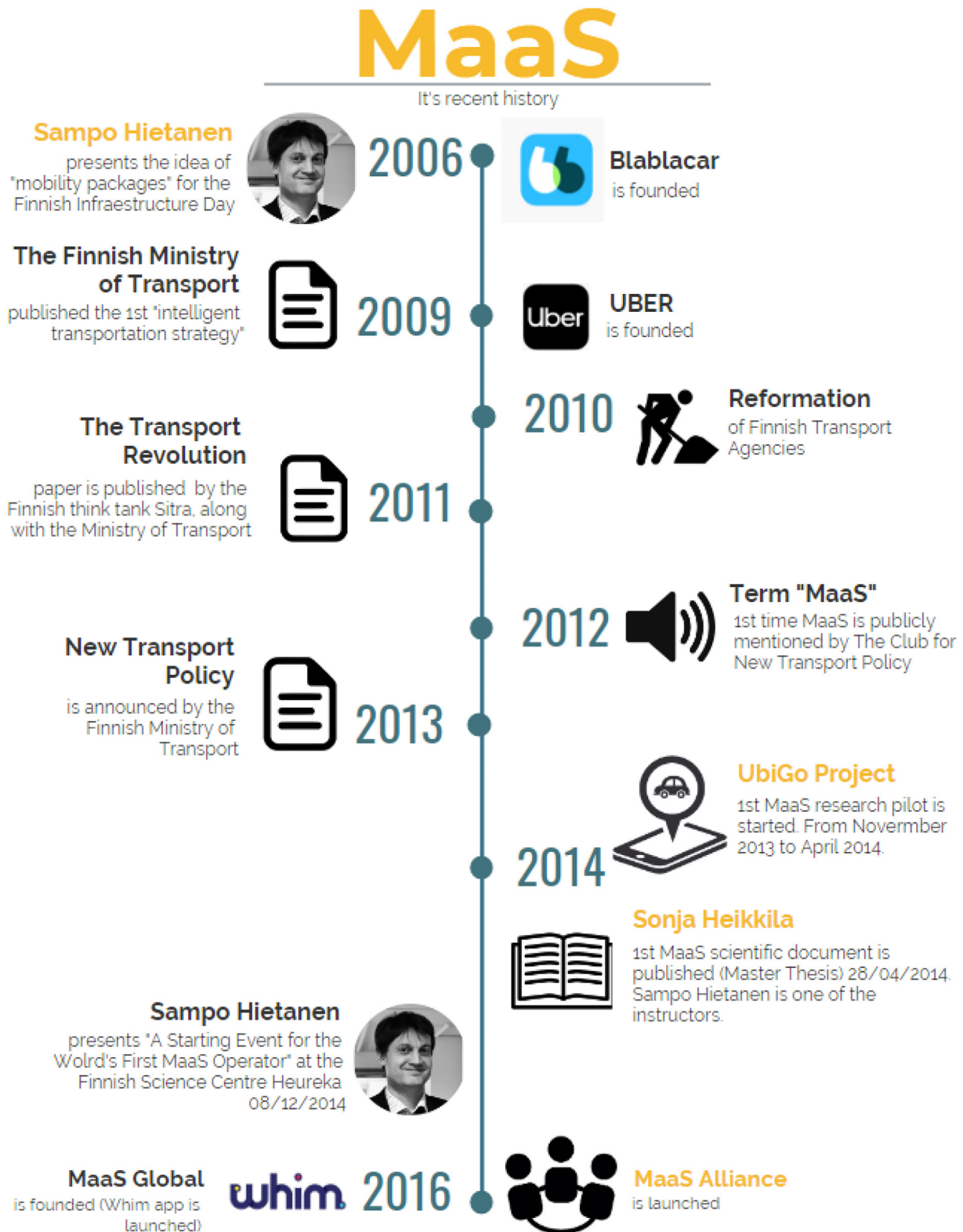


Fig. 2. Brief timeline of MaaS.
(Source: Author's elaboration.)

this kind of collaborative customisation platform is not viable, because it will result in a demand for a large variety of products that may be too difficult to produce. However, Kamargianni et al. [40] state that precisely the contrary applies to MaaS: as it is not a physical product, but rather a service that offers accessibility (hours, euros, km, etc.), variety is highly recommended.

Different users may have different requirements: business travelers, for example, may value reliability, timeliness, exclusiveness and privacy, whereas a student may seek affordability and the social/environmental qualities of ride sharing [41,72]. This potential conflict of interest in MaaS attributes highlights the need to develop a service that combines choices for targeted groups, in accordance with

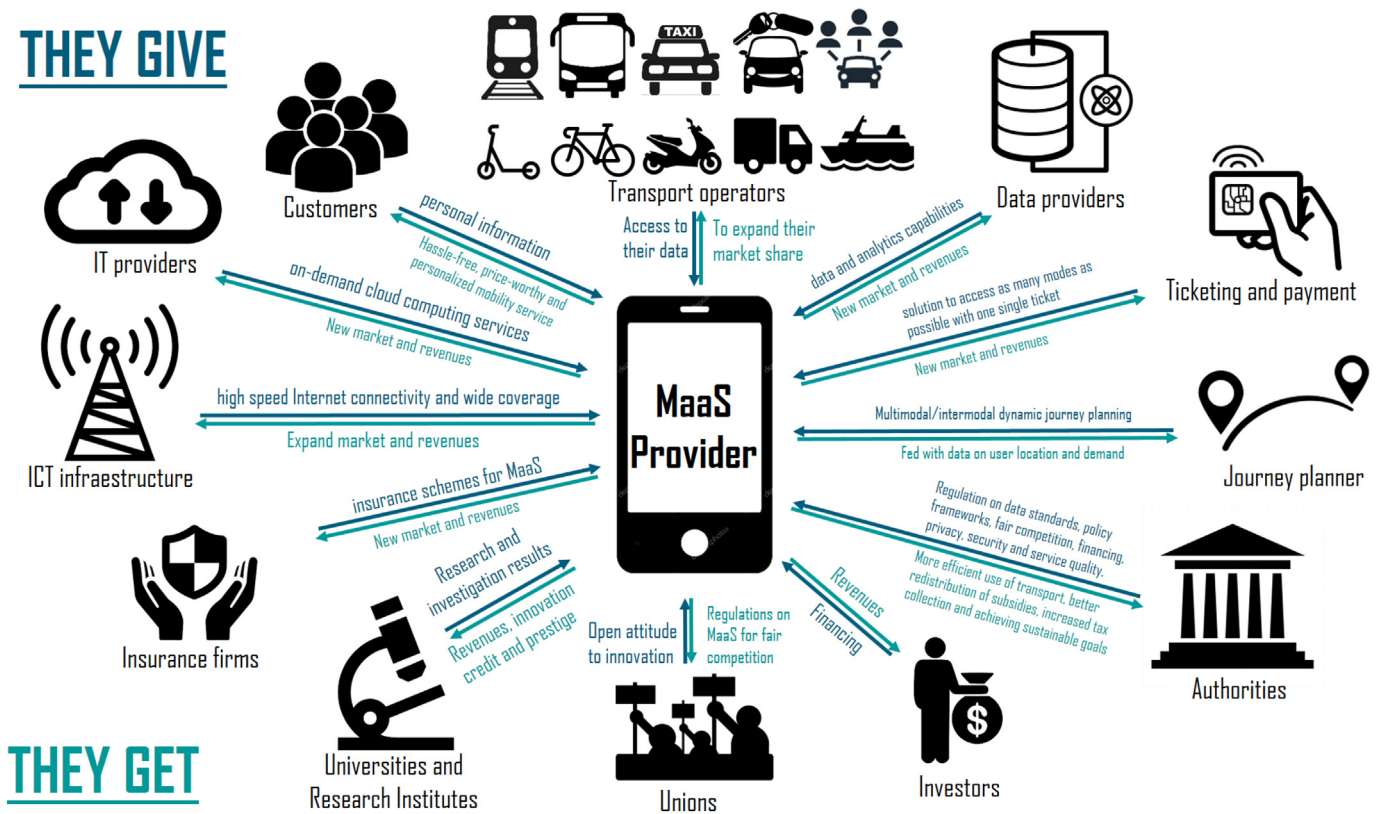


Fig. 3. MaaS ecosystem (what actors give and get).
(Source: The authors, based on (Kamargianni & Matyas, 2017).)

their age, reason for travel, and present travel behaviour [33,39,42,43].

Some studies have achieved an initial segmentation of MaaS users [57–70]. Sochor et al. [44] identified four types of users: a) car shedders, b) car accessors, c) simplifiers and d) economizers. Car shedders were users with a car that wanted to attempt to live without it for economic reasons and parking hassles. Car accessors are those with plans to buy a car in the future, exploring whether they need one. Simplifiers and economizers did not have a car; the former used many mobility options, and the latter were mostly public transport users. At the end of the trial, they all drove less than expected. Some stated that they will delay purchasing a car, and other started using public transport after they found out it worked well. In another type of classification, Robinson [45] identified eight profiles (5 as driving segments and 3 as non-driving segments). His findings show that males, high-income earners and families with children are socio-demographic factors that decrease willingness to join MaaS. On the other hand, low-income earners, not having a car, being young with no children, and environmental awareness are factors that increase willingness to join MaaS.

Differences appear when characterizing MaaS users. Most studies estimate that young people are the most probable early adopters of MaaS [33,46]. However, some show a little scepticism, arguing that young people do not have such complex mobility patterns and that they have limited budget, whereas business travellers or tourists could be more interested [3]. From recent findings, users and especially young people, seem to care more about affordability; they are aware of environmental issues, but if the sustainable option is not price-competitive, then they will choose the cheaper option. If MaaS is more expensive than their current travel expenditure, they are less likely to join [47]. Prior behaviour is also important, meaning that customers are more willing to choose the modes they have tried before; this becomes important when considering strategies to promote active

modes (walking, bikes and scooters); e.g., the first 30 min are free for some bike sharing systems [48].

In most MaaS-pilots, public transport services stand as the most important mobility option. Other important features are the amount of mobility options included (the more modes, the better) and real-time information [49]. Other requirements also need to be considered: seats for children or specialized services for collecting others and travelling to hard-to-reach locations [50].

7. The “how” of MaaS: implementing mobility as a service

7.1. What is driving MaaS? What is limiting MaaS?

MaaS is enabled by certain global factors that have currently been set in place in the globalized, tech-driven servicizing era [13]. The need to do more with less, has enabled the sharing economy. Millennials are the first digital native generation, accustomed to technological advances and more interested in services than in assets [13].

Technological changes cannot be called “dynamic” anymore, but rather “disruptive” due to the speed of innovation with the rapid penetration of smartphones, increased confidence in mobile/digital payments, the development of journey planners with GPS and geolocation technology, and the internet of things which involves big data, connectivity and cloud computing science [18,51]. All of these elements have enabled the informational, transactional, operational and physical integration of transport. Additionally, in the near future, 5G networks and automated vehicles could allow MaaS to grow and consolidate [18].

Nevertheless, MaaS is also still limited by certain factors, such as technological aspects (standardisation of data formats and APIs), regulation, and especially, poor public-private collaboration [46]. The reviewed authors agree that cooperation is the most important challenge to overcome. They argue that public transport operators might try to cling to their current operational models and their monopoly

positions because they are afraid of losing control/influence and brand exposure when participating in MaaS [33,40,52–54]. The brand-exposure problem is that transport operators who decide to join MaaS are not going to handle the MaaS front-end, but rather the MaaS Provider. The same thing occurs with users' primary relationships with Facebook, Google or Amazon, and not with the computer manufacturers or the networking companies that power their data centres [53]. Others argue that opposing objectives in private and public organisations may also be a barrier for collaborating; public entities wish to decrease pollution and private vehicle usage and increase public transport (PT) patronage, while the private sector aims to increase revenues, even if this is achieved by increasing the use of private vehicle (especially car-sharing and rental, which is more profitable than PT) [53,55].

Finally, another challenge for MaaS mentioned is public transport funding. The authors argue that as public transport is the backbone of MaaS, and a subsidized service, it would not allow the MaaS Provider to make profits from selling public transport tickets [3,23,54].

7.2. What is necessary for MaaS?

In order to implement MaaS, certain basic requirements are necessary. We might outline: a wide range of diverse transport modes, physical integration of modes, schedule integration, spatial and temporal coverage of the service (24 h in city/suburbs), data sharing, a strong data privacy policy, MaaS regulation (third-party ticket selling, data exchange standardisation formats and fair competition aspects), funding re-arrangement and willingness of citizens to join. In a broad sense, as stated by Kamargianni and Goulding [29] there are five key “raw ingredients” required for MaaS:

- (1) Transport services and infrastructure: how prepared the current transport system is for MaaS. This includes the variety of modes available, the density of services, the frequency of services and the integration of services.
- (2) ICT infrastructure: penetration of MaaS-enabling technologies. This includes internet access and smart ticketing infrastructure.
- (3) Transport operator openness and data sharing: the extent to which transport operators share data and make APIs available to third parties. This includes whether data and APIs are made “open” (i.e. freely available to use, redistribute and alter).
- (4) Policy, regulation and legislation: the extent to which key policies, regulations and laws to support MaaS are in place. These may be at a city level or a national level.
- (5) Citizen familiarity and willingness: the extent to which citizen lifestyles and behaviour align with a MaaS model of transport provision. This includes travel behaviour and use of MaaS-related technologies.

7.3. How can MaaS be organised?

Apart from basic requirements, some studies explored how MaaS could function or operate from the stakeholders' perspective. Hensher [42] proposes a MaaS business model called the “Three Bs”: bundles, budgets and brokers. By bundles, he means that mobility packages could enable providers to cross subsidies between mobility options. With budgets, he emphasizes the need to understand end-user preferences and willingness to pay for MaaS when setting prices. And lastly, brokers highlight the importance of considering potential new stakeholders and hybrid multi-modal contracts to allow as many investors as possible.

Besides these initial principles, a MaaS scheme could be arranged in three different ways: market-driven development (entirely private), public-controlled development (entirely public) and public-private development (mixed) [53]. The rule seems to be: “too much regulation might impede the private sector's ability to participate and innovate,

leading to unattractive MaaS while too little regulation might lead to not serving the public interest” [53].

8. The “why” of MaaS: its benefits and possible impact

MaaS benefits are still uncertain, due to the lack of massive evidence based on MaaS pilots [56]. However, one of the most expected benefits is the possibility of achieving higher service quality and competitive pricing, since transport operators will gain detailed data from user travel preferences and profiles, resulting in a wider service offer and prices that are adapted to each individual. The MaaS app could also serve as a channel for the demand and supply side to have constant feedback, improving the system [33]. From the users' point of view, a single platform eliminates the hassle in accessing mobility information, ticketing or payment through multiple operators [15]. Having mobility expenditures centralised and pre-planned, and being exposed to different modes of transport every day, could make users' travel behaviour change positively towards more active modes, working as a continuous informational campaign [27,51].

Environmental benefits may include the reduction of private vehicle usage, and thus congestion, although this is still uncertain as stated by Pangbourne et al. [56] points out that MaaS may be unsustainable if it competes against active modes and public transport rather than private vehicles. One of the most oft-mentioned MaaS negative possible effect is having a low percentage of car drivers joining MaaS and, consequently, MaaS becoming a potential competitor of public transport (public transport users may shift to taxis or car-sharing; users cycling and walking may shift to public transport, taxis or car-sharing) [33,34,55]. Hopefully, however, MaaS will contribute to a more sustainable mobility as Ubigo's trial version showed, where 36% of non-car owners stated that they will delay purchasing a car, and 35% of regular car users stated they will shift to public transport, 17% to bicycle, and 17% to walking [27]. If MaaS really takes down car trips, the reduction of car possession could lead to an increase in freed parking spaces and infrastructure that could be used to promote active modes (constructing bikeways, public spaces, etc.) [28]. Social benefits are still highly uncertain as many people do not own bank accounts and may be digitally-illiterate with smartphones and different applications (which is the case for many elderly/disabled people) [56].

For MaaS to be economically profitable, many authors recommend offering the service not only to customers, but to administrations and other companies (Business-to-Administration and Business-to-Business services) who desire a more sustainable commute for their employees [16,37]. To earn revenue, König et al. [25] describes that the MaaS Provider could purchase a significant amount of public transport tickets (bulk or volume purchase), receiving discounts and obtaining a marginal profit by reselling the tickets at the normal price. On the other hand, with private shared mobility services, they recommend charging commissions to transport operators for reselling tickets. And finally, third party advertisements, selling data on customers' preferences and other fees in transactions [16].

9. Discussion and conclusions

As an innovation, MaaS could change the way we conceive transport. All “raw ingredients” related to public-private collaboration, technological advances and socio-demographic aspects may be, in the near future, ready “to cook” MaaS around the world. We seem to be in the Netflixing of transport or “MaaS-sifying” era. As a contribution, this bibliographic review has addressed the topic from a holistic, general point of view, answering the typical W questions.

The “what” of MaaS is still under development, but we can highlight that it is a system that will offer mobility services that could allow users to plan, pay and access their mobility requirements whenever they want in a single application [29].

MaaS pilots' evidence is still scarce, and so benefits and impacts are uncertain. MaaS ecosystem will continue to grow as the concept is more consolidated, for which basic conditions are needed, including a wide range of diverse transport services, infrastructure, ICT and informational integration, technology and collaboration between public and private organisations. For this latter condition to take place (stakeholder's collaboration), they will have to understand MaaS' concept and what it implies, for which we believe this general overview may be of help to "speak the same language" on MaaS.

Limitations in this review involve the limited time capacity to further explore individually each W-question, which could be a future research line. From here on, the main challenges lying ahead are to promote new MaaS pilots to gain more data and develop more research regarding user travel behaviour and preferences for segmenting the market. Other lines of research include modelling MaaS and the user's travel choices. The exploration of MaaS' impacts (social, economic and environmental) are also important, especially in a dockless electromobility scenario and self-driving cars [2,3]. Studies that explore the willingness of stakeholders to join MaaS, MaaS business models structures and regulation adjustment are also important [52].

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