International Transport Forum

Piecing Together the Puzzle

Mobility as a Service from the User and Service Design Perspectives

184 Roundtable

Discussion Paper

Jana Sochor
RISE Research Institutes of Sweden
Gothenburg

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The International Transport Forum

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Introduction and background

Many public transport authorities are looking to how they can enable better mobility for their citizens, in congested urban settings as well as in poorly connected peripheral communities and rural areas. Mobility as a Service (MaaS) is increasingly being presented as a possible solution in both contexts, although the path forward has proven far more difficult than hoped. Part of this may lie in underestimating the complexities of achieving integrated mobility services, which is often linked to a lack of practical experience in implementing and running MaaS services. To quote one project partner in a MaaS pilot project, who represented a public organisation new to MaaS but with long experience within one transport silo, and who shall remain nameless: "This was a lot harder than we expected". So, what should one expect? Why has the MaaS vision not naturally coalesced?

The purpose of this first discussion paper in the series is to try to understand the bigger picture of MaaS primarily from the user perspective but in an interplay with the service perspective, as the service offer and design inherently affect the use of the service. Questions include: What is MaaS? and What could it be?; Who are the (potential) users? and What do they stand to gain?; and How can related research and tools be utilised by public authorities and transport organisations to more proactively engage in MaaS developments so as to improve sustainability outcomes (ecological, economic and social) for users, public and private organisations, and society.

But first, what has happened (recently)? In 2011, a pre-study called "The flexible passenger" evaluated the business opportunities of and preconditions for a "comprehensive mobility service in metropolitan regions". This work directly contributed to what is considered the world's first test of a commercial MaaS service (UbiGo) in 2013-14 in Gothenburg, although the term MaaS was not popularised until 2014. The project in which that first UbiGo business model was tested was generally trying to take a more holistic, systems approach to a new type of collective transport (versus public transport) – realising that the desired changes in transport have not occurred and probably will not occur by continuing to focus on developing a single mode or shifting from fossil-fuelled vehicles, but could perhaps come about by integrating different public and private transport services, supported by societal trends toward shared resources. A user-centred, problem-solving perspective looked to simplify the administrative side of travel for individuals and their households, recognising that individuals most often need to coordinate their activities with others, which affects the individual's (and household's) travel needs and behaviours.

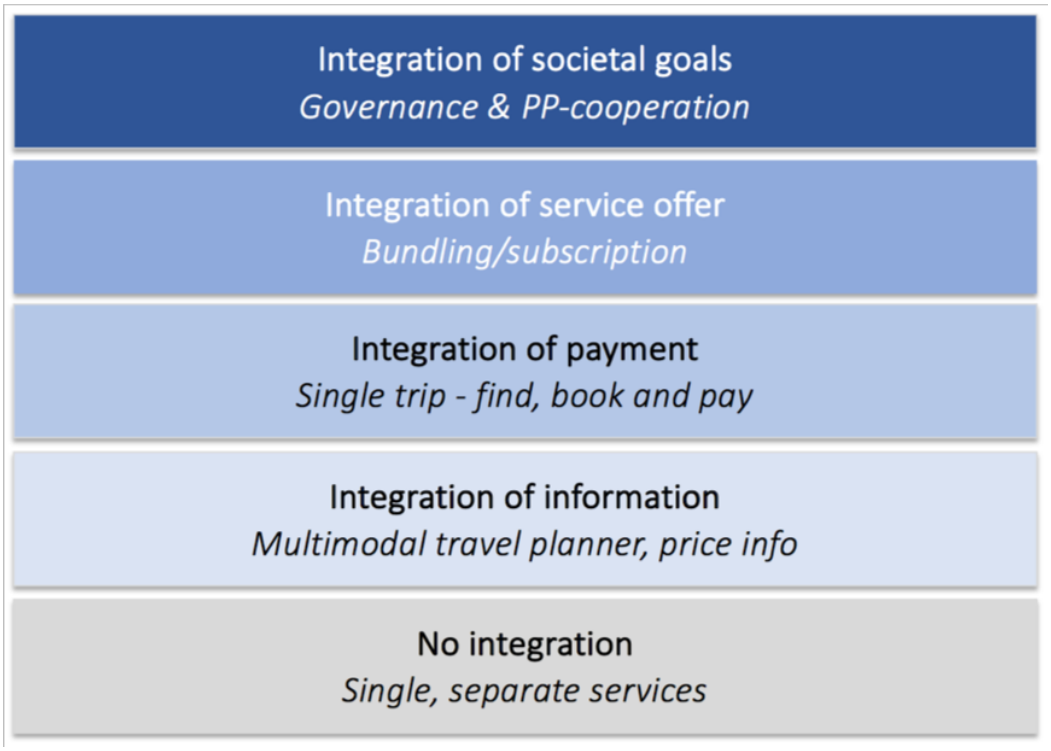
Around the same time, the first public-driven service was piloted in 2013 with Switchh in Hamburg, and MaaS Finland (later MaaS Global) became the first commercial start-up in 2015 with the Whim app launched in 2016-17. At the 2015 ITS World Congress in Bordeaux, expectations ran high that MaaS would revolutionise transport in the near future, but in 2020, nearly ten years since the UbiGo pre-study, MaaS is yet to emerge at scale in any form. The piloted or launched services are generally small in scale (in terms of geography and participants) with very few systematic, empirical evaluations of effects, and success (commercial or non-commercial) remains elusive.

Some troubling signs were already present in 2013-14, e.g. the UbiGo pilot, despite proving popular with its users (e.g. Sochor, Karlsson and Strömberg, 2016; Strömberg, Karlsson and Sochor, 2018), being unable to transition from a commercial pilot to a commercial service largely due to not being allowed to resell public transport tickets. One analysis of the UbiGo pilot (Sochor, Strömberg and Karlsson, 2015) touched upon what has, over time, become more and more apparent, namely, that service integration entailing multiple stakeholders in the transport system has proven more complicated to achieve than had been hoped, that a variety of barriers exist for different stakeholders, and that it can be difficult to align stakeholders' perspectives, including the user perspective.

The MaaS spectrum

To understand the bigger picture and where and how users fit into it, it can first be helpful to understand what MaaS is, as well as what it could be. Perhaps not surprisingly, once the term "MaaS" became hyped, MaaS and various other terms were applied to a wide range of mobility-related services, and many attempted to nail down a definition. In taking another approach, two somewhat conceptually similar, but independently developed, and mutually reinforcing attempts to classify (versus define) MaaS have emerged and become relatively well-known: 1) the "MaaS topology" originally developed in 2016 (Sochor et al., 2018a) that describes five levels of integration (0-4) from the four perspectives of society, business, technology, and users/customers (Figure 1); and 2) the "MaaS taxonomy" by Lyons et al. (2019) that describes six levels of integration (0-5) from an almost exclusively user perspective, albeit a different type, namely cognitive user effort (Figure 2). (Topology levels 1-3 and taxonomy levels 1-5 largely overlap).

Figure 1. The topology of MaaS (levels 0-4, bottom to top)

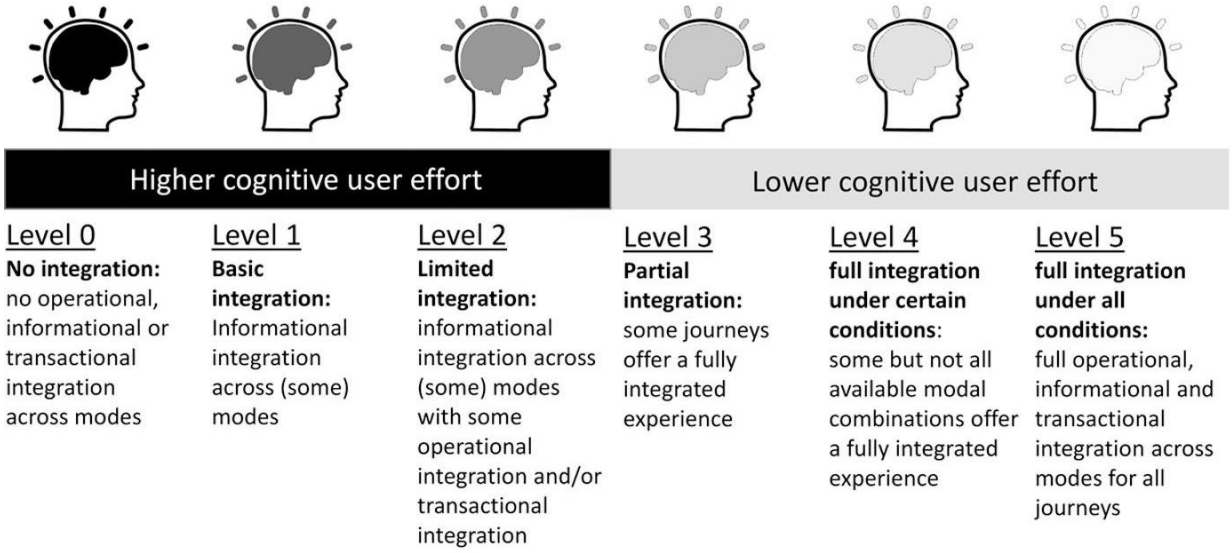


Source: adapted from Sochor et al. (2018a).

From the user perspective, in the topology (Sochor et al., 2018a), the lower levels (0-2) generally offer services that target single trips from A to B, i.e. helping users make choices on a trip-by-trip basis, whereas level 3 services target the total need of a household over the entire year and provide "a comprehensive alternative to private car ownership" (Sochor et al., 2018a, p. 11). In the taxonomy (Lyons, Hammond and Mackay, 2019), the higher the level, the lower the cognitive user effort and at level 5, "MaaS integration provides a mobility system beyond the private car that is on par with the convenience of a private car overall" (Lyons, Hammond and Mackay, 2019, p. 28). One of the biggest differences between the

classifications comes with the highest level (4) in the topology, which entails integrating societal goals into the services, e.g. setting conditions for operators, using incentives to influence more sustainable behaviours related to mode choice, travel time, etc. (Note that the integration of societal goals is placed at the highest-numbered level to indicate it as a vision, although this type of integration could occur in combination with any level). But for both classifications, in general, the higher the level of integration, the more comprehensive and seamless the service becomes for the users, with the potential to offset private car ownership and use (e.g. improving the occupancy and utilisation rates of cars, and reducing the overall number of cars). This is one of the main arguments for (the potential of) MaaS, at least in urban and suburban areas.

Figure 2. Levels of MaaS integration taxonomy



Source: Lyons, Hammond and Mackay (2019).

However, although reduced cognitive load is positive no matter who the user is or what the service entails, another difference between the two classifications is that Sochor et al. (2018a) places a greater emphasis on differences between services; that "not all services are or should be "equal" in the MaaS topology, as they target different customer needs" (Sochor et al., 2018a, p. 13). Also, different level services entail different types of technical integration, business and pricing models, contracts and sharing of risk, types of operator, etc. and "the potential societal effects and business potential are related to the levels" (Sochor et al., 2018a, p.10). For example, level 1 information services (e.g. travel planners) have existed for years, but have never yet proved to be key to offsetting private car ownership and use (as a societal effect). But there is little reason to expect them to, as such services offer support for finding the best trip, on a trip by trip basis (versus a year-round, needs basis). But for urban residents (single or couple) with no children who mainly walk and bike (i.e. with very low transport expenditures), a level 1 service can be perfectly adequate for most additional urban trips, e.g. needing to take public transport once in a while, while a level 3 service (with no pay-as-you-go option or with a minimum subscription level) would be unnecessary as well as economically infeasible for such users, and perhaps even more ecologically unsustainable (e.g. if cars were included in the minimum subscription, even if in some shared form, this could induce demand). Adding level 2 (booking and payment), e.g. a mobility marketplace or one-stop-shop, would add a layer of convenience (or lower cognitive effort), particularly for more multi/intermodal urban households who may want to use cars semi-frequently and/or want to avoid purchasing an additional car, but the service level

would probably still not be holistic enough to offset car ownership as such services still target decisions on a trip by trip basis.

Level 3s focus on the customer's complete, year-round mobility needs, via flexible, tailored bundles/subscriptions, two-way responsibility, etc., becomes more appropriate for households with higher transport expenditures and (potential or actual) car-owning households, particularly households looking to sell their second (or additional) car, households looking to test living without a car for the first time (e.g. empty-nesters with good access to other modes), or even households with expanding transport needs looking to gain access to a car without having to purchase one (e.g. couples with their first child on the way, with good access to other modes). This last line of argument (level 3) is somewhat in line with how Lyons, Hammond and Mackay (2019) frame the likelihood of adopting MaaS (à la Whim) in terms of car access and dependency, with both decreasing the likelihood to adopt. However, the main point of these typified user examples is to illustrate that different services can align better or worse with different mobility needs and that a spectrum of services may be necessary to cover a broad range of mobility needs. In other words, one cannot feasibly separate a discussion of the service offer (and design) from a discussion of customers' needs and requirements, particularly if one wishes to achieve particular goals or effects.

There is much speculation as to if MaaS is a niche product for urban residents, or if MaaS services can be developed for suburban and rural residents as well, as well as for other types of customers. Thus far, most pilots and services, whether private- or public-driven, have targeted urban residents on a business-to-consumer (B2C) basis, presumably the most low-hanging fruit in terms of existing modes and potential customers, e.g. private-driven services such as UbiGo in Stockholm and Whim in Helsinki and other European cities, and public-driven services such as Jelbi in Berlin and SMILE/Upstream in Vienna, etc. It is worth noting there is an uptick in pilots and services focusing on other geographies and types of users or customers as well; a few examples:

- regional or intercity MaaS – yumuv in Switzerland connects options in major cities, allowing people to split their subscription allowance among different providers, and fully functional with location tracking turned off. Also, Renfe as a Service in Spain combining rail trips between Madrid and Barcelona together with other modes for first- and last-mile solutions. A similar service concept exists in France with SNCF national rail.
- cross-border MaaS – In Limburg, Netherlands, MaaS will attempt to provide cross-border alternatives and payment systems so as to reduce car dependency and use.
- rural MaaS – In Groningen-Drenthe, Netherlands, MaaS will utilise empty capacity within special transport services linked to public transport and other mobility services. In Sweden, DalMaaS allows one to book empty special transport trips as well as organise ridesharing, and the KomILand pilots in three small towns include using an app to plan and book trips via ridesharing, public transport, carsharing, cargo bike rentals, etc. In the North Sea Region, eight different living labs in the Stronger Combined project will focus on ideas involving special transport services, village hubs, opening up school buses to the public, improving links from the train station or different districts to the local hospital, ridesharing as a first- and last-mile connection to public transport, etc.
- MaaS for employees – Jelbi in Berlin is extending the current MaaS system to allow for business accounts so that employers can offer employees travel allowances. In Zuidas, Netherlands, where many companies are based, commuting and business trips are creating too much congestion, reducing the attractiveness of the area (and the area's employers), thus MaaS can be a way to help shift trips from company cars to public transport. And in Sweden, MoJo in Johanneberg

(Gothenburg) offers MaaS for local business trips, invoiced directly to the employer, with modes available at local mobility hubs, and LIMA in Lindholmen (Gothenburg) has a similar set up as MoJo (but with similar employment hub-related problems as in Zuidas, Netherlands), although employees (and their families) can also become private customers, and employers can access a "dashboard" to help them follow up on costs and environment and travel policies.

- MaaS for tenants – EC2B in Sweden is a housing-based concept/service in which residential complexes provide MaaS integrated into the housing fee (discussed further below).
- MaaS for events and tourism – In Norway, as part of the Stronger Combined project (see above), demand-responsive options will connect public transport to major hiking routes.
- MaaS for vulnerable users – In Twente, Netherlands, special transport services will be provided in conjunction with more traditional transport services, so as to create a MaaS offer accessible to everyone (accessed via an app or by telephone).

Understanding users and what MaaS can offer

Mobility as a Service could help to shift focus from offering transport (moving something from A to B) to offering mobility (being able to move about freely and easily). But just as mobility is about more than the existence of many modes of transport, MaaS (especially in its more highly integrated forms) is more than a technical interface (e.g. an app) overlaying (a subset of) available modes. Although physical and digital infrastructures are clearly necessary to provide MaaS, a tech-led approach is not sufficient to understand how and why people make choices to use a service or a mode, nor to design MaaS services to meet people's needs. Mobility also relates to the quality of the transport experience; that it is accessible, affordable, efficient, safe, sustainable, etc., but what is "affordable enough" (for example) differs from person to person. Here one can also consider motility, or the capacity to be mobile, sometimes more narrowly viewed as a personal capacity (related to e.g. physical or financial factors), and sometimes more broadly viewed a general capacity (also affected by e.g. technology and telecommunications systems).

A useful model to understand what affects individuals' mobility choices and behaviours is that of "action space" which describes "the actions that are available for an individual to act upon in order to realise their goal" (Strömberg, 2015, §5.2). The model distinguishes between three different types of action space, constrained by different factors: 1) the *actual* action space or what is *objectively* possible, which is constrained by context, resources and capabilities (e.g. infrastructure, mode access, legal constraints, physical and cognitive abilities, financial resources); 2) the *perceived* action space, or what is perceived to be possible, which is shaped by "knowledge" (e.g. awareness of available options, habits, stress); and 3) the *considered* action space, or what is *subjectively* possible, which is constrained by e.g. identity, values and competing needs. For any action to be potentially undertaken, it must fit within all these spaces, i.e. an individual must be able to undertake an action *and* perceive it as possible *and* consider it as an option.

Then, diffusion of innovation theory (Rogers, 2003) can provide an understanding of the process by which innovations spread through society by way of adoption (or rejection). Rogers (2003) outlines a five-stage innovation-decision process: *knowledge/awareness* (exposure to the innovation but lacking information

on it); *persuasion* (interest in the innovation and seeking information on it); *decision* (weighing advantages and disadvantages and deciding whether or not to try it out); *implementation* (trying the innovation to varying degrees and determining its usefulness); and *confirmation/continuation* (deciding to continue or stop use). Strömberg (2015) expanded upon this model by breaking down the implementation stage into two stages: *acclimatisation* (getting to know the innovation) and *normalisation* (using it on a regular basis and fitting it into one's own circumstances). According to Rogers (2003), any potential adopter evaluates the innovation based on characteristics of the innovation, including its relative advantage (compared to the adopter's existing solution), its complexity (if it is easy to learn), its trialability (is it easy to try out), its observability (are others doing it), etc. Adopters are generally classified into categories according to when they adopt the innovation, earliest to latest: innovators, early adopters, early majority, late majority, and laggards, and attempts have been made to classify potential MaaS users into these adopter categories~~: knowledge, persuasion, decision, acclimatisation, normalisation, confirmation (Rogers, 2003 amended by Strömberg, 2015)~~.

MaaS research has been largely constrained to studying pre-conditions, needs, requirements and the equivalent of the knowledge/awareness stage in the innovation-decision process due to the, thus far, limited opportunities for empirical study. A plethora of questionnaire, interview and stated preference studies from various countries have attempted to identify characteristics and traits of potential users (or adopters). It can, however, be difficult to compare the findings, which do not always align, perhaps due to methodological differences, e.g. how MaaS is described to the participants. For example, a Swedish study identified residents of larger cities, younger persons, women, frequent users of public transport or multiple modes as more attracted to the MaaS concept (Sochor, Sundqvist and Lindahl, 2018b), while an analysis of Finnish data identified urban households, persons living alone or with parents, women, lower-income households, frequent public transport users, users with high-quality public transport access, and non-car owners or infrequent car users (Sochor and Sarasini, 2017). An Australian study indicated young and middle-aged individuals, single or married, with or without children at home, and those with higher socio-economic status (education and employment) as more willing to use MaaS (Vij et al., 2020), while a Dutch study found Early Adopters more likely to be urban residents, younger and healthier persons with active lifestyles, persons with higher socio-economic status (education and income), and public transport users (Zijlstra et al., 2020). An analysis of a Swiss household survey identified (depending on the scenario) higher education, use of public transport, experience with carsharing, plans to reduce car usage and pro-environmental attitudes as significant (Hoerler et al., 2020). Overall, living in urban or denser areas is likely the most commonly identified socio-demographic characteristic of those deemed more likely to adopt MaaS, along with younger persons, and persons with a higher level of digital maturity, and perhaps women; results on income vary. (Mode-use characteristics are discussed below).

Some stated preference studies also identify thematic indicators or factors, sometimes more related to needs, requirements or added values of the service than to characteristics of the individual or mode use. A Dutch study denoted their findings as innovativeness, being tech-savvy, needing travel information, having a multimodal mindset, and wanting freedom of choice (Zijlstra et al., 2020), while a study based on German data identified innovative, technology-loving "multi-optionals"; "flexible car lovers" and "ecological bicycle and public transit-lovers" (Hinkeldein et al., 2015). A UK study designated their themes: car dependence, trust (e.g. in the service and technology, which is influenced by digital readiness), human element externalities (e.g. potential safety and security issues related to shared/public transport), perceived added values and cost (Alyavina, Nikitas and Njoya, 2020). (Added values are discussed below).

Commonly identified mode-use characteristics associated with likely adoption generally include more public transport use, more multi/intermodal trips, more carsharing experience, and less private car use or non-ownership. However, this can be too simplistic a representation of the situation as such characteristics

do not necessarily entail enablers or barriers to adoption per se (particularly use/non-use or ownership/non-ownership). Rather, it is the context of use and ownership, as one needs to consider other factors such as congestion charging and availability and cost of parking (often related to geography), tax incentives for company cars, etc., the MaaS service offer and design, and the motives and expectations of the users of the MaaS service. In Rogers' (2003) diffusion of innovation theory, it is the overall relative advantage (or disadvantage) that must be considered, as if and when private car use and/or ownership becomes too disadvantageous, it can push people to other solutions and become an enabler of MaaS adoption. (And public authorities hold the lion's share of responsibility in making private/non-shared/fossil-fuelled car ownership and/or use relatively more disadvantageous).

For example, a study on Londoners' attitudes found that many car owners and users wanted to have access to a car without owning one due to expense, congestion, difficulties parking, etc. A large majority thought ownership was unnecessary and a hassle (Kamargianni, Matyas and Li, 2017). There also exists empirical evidence questioning an overreliance on pre-MaaS mode-use characteristics to predict MaaS adoption. An analysis of the UbiGo pilot based on ex-ante car ownership/access identified and compared four subgroups: car shedders who owned one or more cars but decided to set one aside during the pilot, i.e. they wanted to test having access to a car without owning it; economisers who owned one or more cars but who kept their car(s) during the pilot and wanted improved access public transport, etc.; simplifiers who did not own a car but were ex-ante carsharing members, who thought UbiGo would be a smarter way to manage their mobility; and car accessors who neither owned a car nor were they ex-ante carsharing members, i.e. they wanted to gain access to cars. Despite all these subgroups falling into the same main target group (urban households with a certain level of access to the included modes and expensive enough travel needs for the service to be economically competitive), the identified subgroups had very different preconditions, motives, expectations and learning experiences (outlined in more detail in Strömberg et al., 2018). Despite this, there were no statistically significant differences in terms of various measures of satisfaction, with high levels of satisfaction overall.

In terms of who MaaS users have actually been, thus far, there are very few widely available findings from pilots and services. A questionnaire analysis of SMILE (level 2; see Figure 1) found that pilot users were not representative of the population of Vienna, but concluded that gender- and age-wise, they matched so-called Early Adopters in the Vienna area (majority male, 20-40 years old with a university degree). Furthermore, a majority owned a bicycle and car and had a yearly public transport card (https://smile-einfachmobil.at/pilotbetrieb_en.html). An interview study of EC2B users (MaaS for tenants, level 2; see Figure 1) found that few active users were older persons, perhaps because older persons in Gothenburg get free off-peak public transport and are less inclined to ride bicycles (e-bikes, cargo e-bikes, and an e-moped are part of the EC2B offer at this location). From the UbiGo pilot (level 3; see Figure 1), an ex-post analysis of the participants (Karlsson et al., 2017) found that, compared to the population in Gothenburg municipality, gender split and cars per household mirrored the overall population, while couples and families with children, employed persons, and persons with a post-high school education were overrepresented. Likely related to the economic feasibility of the minimum subscription, single-person households and retirees (and students to a small extent) were underrepresented. An overrepresentation of families with children could perhaps come as a surprise, but interviews suggested that shared options become particularly problematic with multiple small children (i.e. when needing multiple car seats). More UbiGo participants lived in the city centre, but the pilot did not intend to mirror the population, but rather to offer a service to households with good access to carsharing and public transport (and high enough mobility expenditures for the offer to be economically competitive), and such access is more likely to be found in the city centre. As discussed above, four participant subgroups were also identified, namely car

shedders, car accessors, economisers and simplifiers, all of which perceived relative benefits, albeit different ones, from using that MaaS service.

A few empirical studies on actual MaaS users have also explored users' motives (or drivers). Motives can also be framed in terms of perceived relative benefit (or added value from a business perspective). According to Rogers (2003), rapid adoption of an innovation (in the case of MaaS, adopting both the service and potentially new behaviours) depends on its relative benefits compared to the existing solution. Thus, MaaS must be perceived to be better in some way(s), proportionate to the costs (e.g. money, effort), compared to the current way of doing things. Perception is the key here, as different users will assess the same offer differently. A potential user needs to perceive some potential value in order to become a user and perceive some experienced value in order to remain a user.

Questionnaire responses from Whim users (on motives to remain a user) included main motives such as "*price, ease of use and convenience, flexibility and the selection of different transportation modes*" but not environment (Luukkainen, 2020, p.70). In the UbiGo pilot in Gothenburg, the strongest primary motive going into the pilot was, by far, *curiosity* (63% of participants), with all other factors significantly lagging behind (curiosity was also the most common motive among non-participants, who expressed interest in the pilot but who eventually did not become participants, but not to the same extent). But as curiosity fades over time, it is important that other perceived benefits continue to motivate users. In the case of UbiGo, by the end of the pilot, *convenience/flexibility* had become the strongest motive to keep using the pilot (Sochor, Strömberg and Karlsson, 2014) followed by curiosity and *economy*. Much like the Whim findings, environment was rarely a primary motive. Rather, it was considered something of an added bonus if using the service enabled more environmentally friendly travel. And finally, in analysing interviews with users of the EC2B MaaS service for tenants in Gothenburg, Smith, Sochor and Karlsson (2019) found that they were largely driven by curiosity in the decision and acclimatisation stages of the innovation-decision process (as discussed in the section "Understanding users and what MaaS can offer"), but for those who managed to reach the normalisation stage (i.e. active users), the main drivers shifted to more *flexible travel, saving time and hassle*, etc. (A discussion of the flip side, the barriers, can be found below).

Some stated preference-type studies also delve into what participants think they want from MaaS, although it can be difficult for participants to speculate on what might not only be a new service but also a new way of organising their own (and their household's) transport. Alyavina et al. (2020) group a range of items under potential "value", such as the one-stop-shop concept including information, booking and payment; the potential to help participants change routines and habits; use of data analytics to improve the travel experience, etc., although these were qualified with MaaS needing to provide at least as good a level of service as the current solution(s). Hoerler et al. (2020) asked about ideal service characteristics and the most popular responses were: spontaneously available, cheaper than the current solution, fast/short transfer time, independence, simplicity/ease of use, and close to home/door-to-door service. A Swedish study (Sochor et al., 2018b) identified, via interviews, four requirements to simplify daily travel: offer tailored solutions to daily challenges; minimise stress and uncertainty; provide a safe, secure, pleasant, comfortable, convenient trip; and make it easy to test new options and solutions. Four principles were also outlined to help in fulfilling these requirements: *personalisation* so as to enable a better match between the service offer and a user's/household's needs; *ease of use* so that the service and app are easy to use and understand; *reliability* in terms of technology, information, time (timeliness and being on time) and the overall experience; and *low thresholds* for getting started and testing new modes and behaviours.

Turning back to empirical studies discussing added value, a student thesis analysed value creation based on questionnaires to Whim customers. The 257 respondents from the Uusimaa region (where Helsinki is located) were a majority male, 20-50 years old (average age of under 40) and did not own a car. Identified

service attributes contributing to value creation included *available modes, price, ease of use, customer experience, customisation, flexibility, convenience, increased safety and reliability, innovativeness, and environmental responsibility* (Luukkainen, 2020). Many of these findings overlap with those from the UbiGo pilot in Gothenburg (six months with 195 users in 83 households), where an analysis identified service attributes that were considered to have contributed to the pilot's success (Sochor et al., 2016): 1) the *"transportation smorgasbord"* concept with a household subscription package covering the majority of one's travel needs and centralised customer support; 2) the *simplicity* of the service including how one managed tickets and bookings, a customised, modifiable household subscription with one monthly invoice providing an overview of transport expenditures, the type of public transport tickets (daily) and zones (simplified), etc.; 3) improved *access* with easier access to more modes, including greater mental accessibility due to increased knowledge of the alternatives via customising one's subscription and choosing from the list of options on the app; 4) improved *flexibility* due to multiple alternatives combined with reduced sunk costs, which led to participants feeling they could better match their choice of mode to each individual trip's requirements, and increased spontaneity; 5) *economy* including the close to pay-per-use subscription, which meant that transport costs became more transparent and involved fewer sunk costs. In terms of the UbiGo pilot's added values or relative benefits, they involved the above (economy, flexibility, accessibility, simplicity). Although not a service attribute per se, the analysis also identified *trialability* as a factor in the UbiGo pilot's success, in other words, the service design allowed for actively trying out new behaviours at relatively low risk. Participants tested new modes, tried gaining access to cars without having to purchase one or tried living without a car (the pilot allowed participants to temporarily set aside their car and be partially compensated for depreciation), etc. And a consequence of this trialability was participants gaining new insights into what *convenience* meant for them; for some, a private vehicle close at hand, but for others, gaining access to a car fleet and not having to deal with the hassles of a private car (maintenance, parking, etc.) (Sochor et al., 2016; Strömberg et al., 2016).

One can also flip the discussion as a way of seeing how these values and attributes can become barriers to adoption instead if they do not offer perceived improvement over the current solution. MaaS cannot be more expensive without enough added value to justify the increase in price. MaaS cannot be perceived as more inflexible, inconvenient or inaccessible, but public transport, carsharing and bikesharing can be perceived as such by people on call, who live "too far away" from the physical infrastructure, or who have multiple small children (i.e. car seats). MaaS must be "easy enough" to understand and use, e.g. the time and effort of learning the ins and outs of being a customer, onboarding processes, using the app, accessing vehicles, etc. Indeed, barriers can arise all along the innovation-decision process, both pre-and post-decision, i.e. some barriers keep potential users from even considering MaaS in the first place, such as poor access to the included modes or reluctant family members, while other barriers will arise while trying to use the innovation and seeing how well it fits into one's life, such as identifying mismatches between one's needs and the offer, or some negative experience. Smith, Sochor and Karlsson (2019) identified barriers in four phases of the innovation-decision process for the EC2B users (MaaS for tenants). Some examples: in the persuasion stage (information seeking), barriers included a low perceived need for the included services and/or app, or perceiving the included transport services as insufficient; and in the decision stage, a tedious onboarding process acted as a deterrent. In the acclimatisation phase, users found the service hard to learn in terms of practicalities (app, procedures and even handling the vehicles), and in the normalisation phase, users found the booking system inadequate (e.g. being able to book specific vehicles or extend bookings), missed app functionalities such as a travel planner, and had difficulty accessing electronic keys due to poor mobile coverage in the garage (see Smith, Sochor and Karlsson, 2019 for more examples).

In an analysis on the value of trials (or pilots) in terms of creating trialability and supporting the users' process of adopting new travel behaviours, Strömberg et al. (2016) recommend focusing on removing barriers rather than on offering incentives. Although both can motivate people to try out a new service, offering incentives does not lead to trialling new behaviours under as realistic conditions as does removing barriers. When incentives disappear after the trial, there is a tendency to revert back to one's previous behaviour. Trials also need to be long enough to break old habits, form new habits, discover problems and work out solutions, and experience the service under variations in season and weather, in other words long enough to potentially work one's way through the entire innovation-decision process, as too short a trial will also make it easier to revert back to one's previous behaviour. Furthermore, as barriers can arise all along the innovation-decision process, it is crucial to offer support throughout the process and not just up until the decision stage (e.g. up until recruitment is completed). For MaaS, this can mean coaching sessions, customer support, making improvements based on customer feedback, flexibility in terms of modifying or changing subscriptions or bundles, etc. Support can also come in the form of creating trialability, as trialling new transport behaviours does not come naturally, particularly drastic ones such as selling one's car. Decisions to change one's own (or a household's) transport behaviour is not taken lightly, as it involves increasing uncertainty and risk with no guarantee of a better outcome. It is therefore important to lower the perceived risks in order to help people dare to try something new. This can occur by offering tests or short-term leases of new vehicles in order to find the vehicle that best matches one's needs, as this is an expensive purchase. Or creating conditions to truly test life without a car before selling it, such as in the UbiGo pilot where households could opt to set aside their car (in care of the project) and receive some compensation for depreciation. (See Strömberg et al., 2016 for more on trialability).

The uncertainties related to becoming a MaaS customer may also play a part in how participants react in stated preference studies on subscriptions, bundling and willingness to pay, which tend to illustrate a hesitancy towards subscriptions/bundles or a leaning towards pay-as-you-go (e.g. Caiati, Rasouli and Timmermans, 2020) and/or emphasise the need to create (customised) bundles which better match needs so as to improve uptake (e.g. Ho, Mulley and Hensher, 2020). As Ho, Mulley and Hensher (2020) observed, the pay-as-you-go model is easier to understand, re-emphasising an earlier point that it can be difficult for study participants (or even potential customers) to speculate on not only a new type of service but also on how well it may or may not meet their transport needs (which they likely have not reflected upon previously, at least not holistically). To further complicate things, there exist so many different possibilities regarding subscriptions and bundles. For example, is it an individual or household subscription? What are the price levels and/or is there a minimum subscription level? What is the cancellation policy? Not to mention mode-specific policies e.g. cancellation/rebooking policies. Is there a pure pay-as-you-go option (which tends to be more associated with level 2 services (see Figure 1)) or not? Are the bundles based on accessing trips/modes (e.g. x number of taxi trips up to y kilometres, accessing discounts (e.g. z percent off taxi trips), or a combination depending on the mode? Who chooses the bundle: the customer or the MaaS operator? In either case, can the user modify or switch from month to month? If the operator, how many bundles are there to choose among? What happens if the customer runs out of credit/trips? Can one top-up for the rest of the month? What happens with unused credit/trips, do they disappear (which will likely induce demand to use them up), or are they rolled over to the next month or are they transformed into some other type of credit/trips? It is no wonder if respondents might lean towards a pay-as-you-go option, particularly in stated preference studies and/or at the start of their customer experience, although subscriptions and bundles can create minimal lock-in effects depending on how they are designed (e.g. cancellable, customisable and modifiable, topping up and rolling over credit).

However, as with so many other aspects of MaaS, subscription and bundles are also about trying to find a viable yet attractive service offer that can meet customers' needs (including flexibility), and there are

advantages and disadvantages with the various options (e.g. pay-as-you-go or not). For example, an analysis comparing stakeholder perspectives in the UbiGo pilot (Sochor, Strömberg and Karlsson, 2015) recognised various trade-offs surrounding subscriptions, etc. – for the MaaS operator, a pre-paid, minimum subscription means advance income, negotiating power, and securing business for the service providers, but for the users, paying in advance is perceived as less flexible, and for society, a minimum price may exclude certain types of users. And although flexibility has been repeatedly brought up throughout this paper as a highly important aspect for users, not all types of flexibility are necessarily good. For example, a purely pay-as-you-go option may be mentally easy to grasp, but it can also reinforce pre-MaaS travel patterns and not challenge users to test new options, thus linking back to the importance of supporting MaaS users along the innovation-decision process. For example, helping customers estimate their transport needs so as to get started (e.g. to customise or choose an initial subscription or bundle), then offering the ability to modify the subscription or bundle once the customers gain a deeper understanding of their needs based on actually using the service. In the UbiGo pilot, despite personal meetings, households still surprisingly (even to them) overestimated their transport needs by 30% for car (hours) and 15% for public transport (daily tickets), illustrating the difficulty in estimating needs. The UbiGo participants also felt that their increased reflection and planning (linked to customising their modifiable subscription) ultimately led to a deeper understanding of their transport needs and more effective planning, which they appreciated (Sochor, Strömberg and Karlsson, 2015; Sochor, Karlsson and Strömberg, 2016).

Finally, turning to the perhaps biggest question related to users, can MaaS actually lead to more sustainable travel behaviour? In all actuality, this remains an open question. What evaluations that exist to learn from (i.e. an evaluation was performed and at least some results shared), are primarily at level 0, namely separate, single services, and not integrated services at levels 2-3 (see Figure 1). For example, a great deal of work has been done on carsharing or bikesharing, and common angles of exploration include mode shift (as well as complementing and substitution), cost, types of customers, etc., i.e. many of the same questions posed regarding MaaS. For brevity, the brief summaries of evidence below will be limited to levels 2-3. Unfortunately, the pandemic has delayed several such pilots and evaluations.

SMILE was a level 2 service in Vienna in 2014-15 with a focus on information, booking and payment of multimodal trips on a pay-as-you-go basis. It included public transport, taxi, carsharing and bikesharing. The service was tested by over 1 000 people, but less than 20% responded to the single questionnaire in 2015. A total of 75% of respondents stated they were content with the service, 48% stated they had increased their use of public transport and 10% increased their use of bikesharing, while 21% stated they had reduced their use of private car and 20% reduced their use of taxi. Of note is that 6% stated they used bicycle less frequently, and 6% used it more frequently, likely reflecting the general testing of new alternatives and combinations. Regarding combining modes, 26% declared more frequently combining public transport and private cars, and 20% public transport and bicycle, claimed to be largely motivated by the SMILE app having indicated the combinations as quicker. (See https://smile-einfachmobil.at/pilotbetrieb_en.html for more information, as well as Karlsson et al., 2017.)

Turin, Italy hosted a MaaS "living lab" in the EU H2020 IMOVE project which encouraged using non-private car modes for commuting and work trips. The level 2 IMOVE Turin service provided access to public transport, bikesharing, shared taxis and e-scooter sharing. Responses from the "end" questionnaire to "citizen" participants (17 responses from 40 participants) indicated that the range of available modes was likely too narrow, as only 27% felt that the current services were adequate and only 38% felt that IMOVE Turin presented many mobility options, while 80% wanted to add parking payment, 47% carsharing, and 40% long-term rentals. Despite this and other issues such as frustration with the app, a slight majority stated they had increased their use of public transport and a large minority stated that they had reduced

their use of private cars. Interestingly, the service did not appear to encourage multimodal trips to any great extent, although the reasons for this could not be elucidated from the questionnaire responses. The two most popular combinations were car and public transport (31% sometimes/frequently/always) and bicycle and public transport (19%). Overall these results indicate room for improvement in the service offer including a mix of modes offering a more comprehensive alternative to the private car, i.e. service design is an iterative process and one will likely need to make improvements even after "going live". However, the general lack of multimodal trips also serves as a reminder that additional infrastructures may be necessary to create the preconditions for such trips, e.g. the creation of mobility hubs (Kershaw and Sochor (uncredited), 2019).

EC2B is a housing-based concept/service in which residential complexes provide MaaS integrated into the housing fee. Viva in central Gothenburg is such a complex, with 132 apartments across six buildings and *no* residential car parking for tenants; only a few guest parking spots. EC2B at Viva is a level 2 MaaS service that includes bikesharing (e-bikes and cargo e-bikes), an electric covered moped, public transport (bus and tram stops nearby), carsharing (electric cars just outside the complex and other types of cars within walking distance), an on-site bicycle garage, including ramp and elevator, charging facilities and repair room. Important to note is that EC2B was introduced as part of an entirely new housing concept, thus it is not possible to isolate the effects of EC2B from the overall effects of moving (to perhaps a new (area of) town) with no available residential parking. For example, 69% of the 29 respondents to the "before" questions on car access had access to one or more cars before the move (31 cars in 20 households), but only 24% planned to have a car at Viva (seven cars in seven households). The 39 "during questionnaire" responses confirmed that moving to Viva had affected car ownership and use with 11% of respondents stating they had sold their car before moving there, and 19% stating they may sell their car in the future. Important factors contributing to this included lack of parking (69%), living centrally (45%) and no longer needing a car due to EC2B (45%). Overall the majority of the "during" respondents were satisfied with EC2B, and a majority stated that they had increased their use of public transport and reduced their use of private cars, and a large minority stated that they had increased their use of carsharing and bikesharing. That no residential parking played such an important role indicates the opportunity to increase the impacts of MaaS on private car ownership and use by introducing it together with other public policies, in this case, reduced parking (Kershaw and Sochor (uncredited), 2019; see also Smith, Sochor and Karlsson, 2019).

The evaluation of the UbiGo pilot in Gothenburg (November 2013 - April 2014) is still one of the most comprehensive (and disseminated) to date with relatively rich user data. The pilot tested a level 3 commercial concept for six months with 195 individuals in 83 households (and 151 persons completed all three questionnaires, "before", "during" and "end"). Each household became a contracted customer and customised their own subscription, invoiced monthly (minimum approximately EUR 135 or USD 185 at the time), including chosen levels of public transport, carsharing, car rental and bikesharing, accessed and managed via a smartphone (with taxi trips invoiced the next month). Monthly credit could be topped up or rolled over, and subscriptions could be modified from month to month. Centralised customer support was provided 24/7, and the public transport comprised daily tickets (not otherwise available) and simplified zoning. Furthermore, participants could set aside their car (in care of the project) with some economic compensation for depreciation. In total 20 households accepted this offer, 17 of which were single-vehicle households (and no one asked for their car back before the end of the pilot).

From the user perspective, the UbiGo concept proved popular, with a large majority of participants becoming more and more satisfied with their travel ("before" 77% satisfied, "during" 88%, "end" 93%, and six months afterwards 75%) and 97% wanting to remain as customers after the pilot. A total of 97% of those who reported behavioural changes stated they were satisfied with those changes, the most common of which were mode (44%), pre-trip planning (34%), destination (22%) and trip chaining (22%) generally

entailing fewer spontaneous trips; 36% reported no changes in behaviour. From the "before", week-long travel diaries (n=40), mode split largely mirrored that of the average central Gothenburg resident, aside from slightly more public transport use and slightly less walking. In the questionnaires, respondents reported decreases in private car use (48% of respondents) and increases in mainly carsharing (57%) and bus/tram (50%). Attitudes towards modes also shifted, where respondents became more negative toward the private car (23% of respondents) and more positive towards other modes, e.g. carsharing (61%), bus/tram (52%), bikesharing (42%). An initial analysis of the travel diaries at the time of the pilot indicated a 200% increase in carsharing use, a 100% increase in express bus use, a 35% increase in bicycle and local bus use, and a 50% decrease in private car use. However, further, more detailed analyses, according to e.g. number of trips (segments) and vehicle kilometres, are currently underway which preliminarily indicate decreases in private car use (in the order of 50% each, trip segments and kilometres) and increases in carsharing (in the order of 70% and 250%, respectively), private biking (in the order of 50% each) and local bus use (in the order of 50% each); and for all car modes together (private car, carsharing, car rental, taxi), an overall reduction in both trip segments and vehicle kilometres. (See e.g. Karlsson et al., 2017; Sochor, Strömberg and Karlsson, 2014, 2015, and 2016; Strömberg et al., 2016; Strömberg, Karlsson and Sochor, 2018 for more information).

These examples certainly indicate promise for MaaS to promote more sustainable transport choices and behaviours, although many questions remain regarding large-scale effects and long-term effects, a deeper understanding of hard and soft factors affecting success, not to mention understanding choice heuristics given the (perceived) larger choice set.

Opportunities and tools

Although sceptics exist, the current thinking tends to view MaaS as an(other) opportunity to approach transport in a more holistic manner, integrating different mobility services, public and private, into solutions offering more comprehensive alternatives to the privately owned *and* non-shared car. However, as discussed in the introduction, MaaS has not emerged as envisioned several years ago (or as envisioned even earlier in the case of approaching MaaS as the latest in an evolution of related concepts such as Advanced Traveller Information Systems and Mobility Management (Hensher et al., 2020; pp. 15-16). MaaS services are yet to prove successful by any measure, such as geographical coverage, number of customers, viable business models (beyond experimenting thanks to either taxpayer funds or venture capital), or sustainability (ecological, economic and social). Perhaps of greatest concern is, assuming MaaS can successfully emerge in various forms, how can it be guided in such a way that achieves a win-win-win situation for users, business and society? There are likely multiple answers which vary according to the local context and type of service, which complicates the decision-making process, particularly given the current state of affairs with services limited in number and scale, limited empirical data, and unstructured, incomparable, and time-limited evaluations, all of which contribute to uncertainty. Although the answer(s) remain unknown, in reality, MaaS governance is already occurring now, whether or not public authorities are taking a hands-on or hands-off approach to it, as legislation, taxation, public policies, visions, and financing are all influencing MaaS developments. Looking at the bigger picture, the main question is how to take steps to move forward in an informed manner, making sure to learn along the way.

Smith (2020) – with inspiration from collaborative innovation and transitions studies together with data from case studies – expanded upon his three possible scenarios for MaaS developments (market-driven, public-controlled and public-private scenario (Smith, 2020., p.89)) regarding what public-sector actors can do if they wish to participate in and guide MaaS developments. First, three principles: establish a long-term vision for MaaS; draft an agenda for MaaS developments and support MaaS experimentation (Smith, 2020, §8.1). (A further 15 sub-activities are outlined regarding how to achieve these principles.)

Then, via case studies, Smith identified opportunities for the public sector (so-called pathways) during different phases of MaaS developments (Smith, 2020, §8.2). This, in order to better capture the ways that the public sector can play both multiple, simultaneous roles, as well as change roles over time (e.g. across the development, diffusion and use phases). The proposed roles, from a more hands-off to a more hands-on approach, are: Laissez-Faire (i.e. business as usual), MaaS Enabler, MaaS Partner and MaaS Promoter. Very briefly, in the development phase, an Enabler could fund MaaS services, a Partner could participate in services as a mobility service provider, and a Promoter could take the lead to develop services. (Note that a public sector actor can simultaneously act in combinations of these, i.e. it is not a matter of one single choice from among the three). In the diffusion phase, the public sector could promote services (Enabler), and/or legitimise services and share data (Partner), and/or act as lead customer (Promoter), while in the use phase the public sector could feed its own data and tickets into MaaS services (Enabler), and/or mediate various mobility service providers' data and tickets into MaaS services (Partner), and/or integrate data and tickets into and operate MaaS services (Promoter). Contrasting real-life examples are identified.

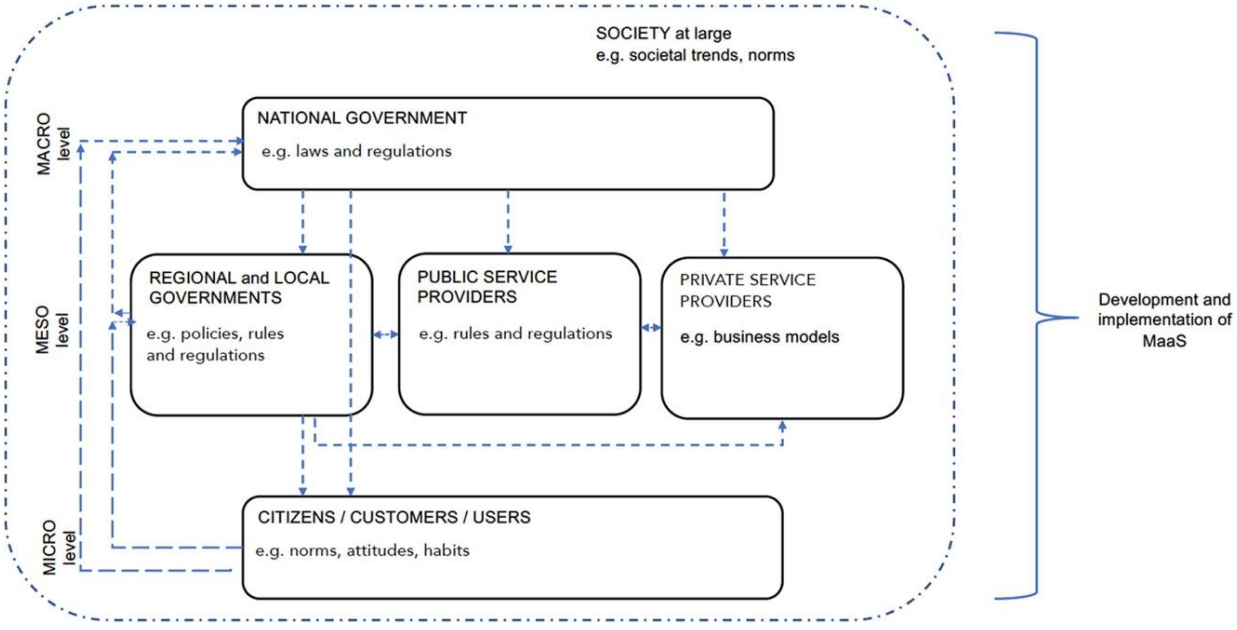
There also exist a number of approaches, tools and methods that include the user perspective in some way. Although the term *user-centric* is often included in the MaaS rhetoric, there is a question as to how that could be actualised in practice. One way could be to utilise such tools so that the user perspective becomes a more consistent presence across MaaS developments (i.e. beyond the typical analyses of mode split/choice, travel needs and customer segments). Some of the tools below existed previously, and some were developed after hands-on experience of delays in, and barriers to, MaaS developments, triggering a realisation of need. A few examples follow.

For agencies who wish to operate, develop or improve MaaS or mobility services, one can adopt a service design approach. In general, this approach entails improving "the experiences of both the user and employee by designing, aligning, and optimising an organisation's operations to better support customer journeys" (https://www.nngroup.com/articles/service-design-101/). A successful design will be relevant and user friendly from the user perspective as well as economically sustainable and competitive from the business perspective. Stickdorn et al. (2018) outline six service design principles: *human-centred*, *collaborative*, *iterative, sequential*, *real* and *holistic*. A broad array of methods/tools exist to take one through the service design process, e.g. customer journey maps, personas and service blueprints to gain insight into the customer (user) perspective.

A complementary approach is the lean start-up methodology (http://theleanstartup.com/principles), first proposed by Ries in 2008, which intends to shorten development cycles and time to identify the viability of a business model. This is achieved via taking a more scientific approach to business development, namely the "build-measure-learn loop", which tests a business model hypothesis, validates (or not) via learning (measuring customer response), makes improvements and iterates this process. Perhaps the most well-known tool or template related to this is the Business Model Canvas (Osterwalder and Pigneur, 2010) which outlines the product or service's value proposition (what the business is offering to meet customers' needs), infrastructure (activities, resources and partner network), customers (segments, channels and relationships) and finances (cost structure and revenue streams).

After observing the complexities of the UbiGo pilot, witnessing the difficulties in aligning stakeholders' perspectives, and generally following the difficulties in achieving MaaS anywhere, a framework was developed to understand the enablers and barriers of MaaS development and implementation (see Figure 3 and Karlsson et al., 2020). The basic framework, visualised in Figure 3, considers both formal and informal factors on three interconnected analytical levels: *macro* (i.e. broader societal and political factors, e.g. legislation and policy instruments); *meso* (i.e. public and private organisations, including regional and local governments, e.g. regulations and incentives, organisational cultures and networks, collaboration and business models); and *micro* (i.e. the individual travel or user, who is influenced by a formal push and/or pull strategies, but also by informal norms, self-image, attitudes, habits, etc.). The framework serves as a visualisation of how the development and implementation of MaaS "requires institutional changes at many levels, within (and between) different organisations" (Karlsson et al., 2020.; p. 292). In applying this framework, it becomes even more apparent that MaaS developments largely hinge on organisational and policy innovations, such as collaboration models, business models, parking policies, taxation, etc. (see e.g. Smith, 2020). This framework can be and has been utilised to identify enablers and barriers within a particular context, as well as to understand differences in MaaS developments across contexts.

Figure 3. IRIMS analytical framework to identify institutional factors (enablers and barriers) affecting the development and implementation of MaaS.

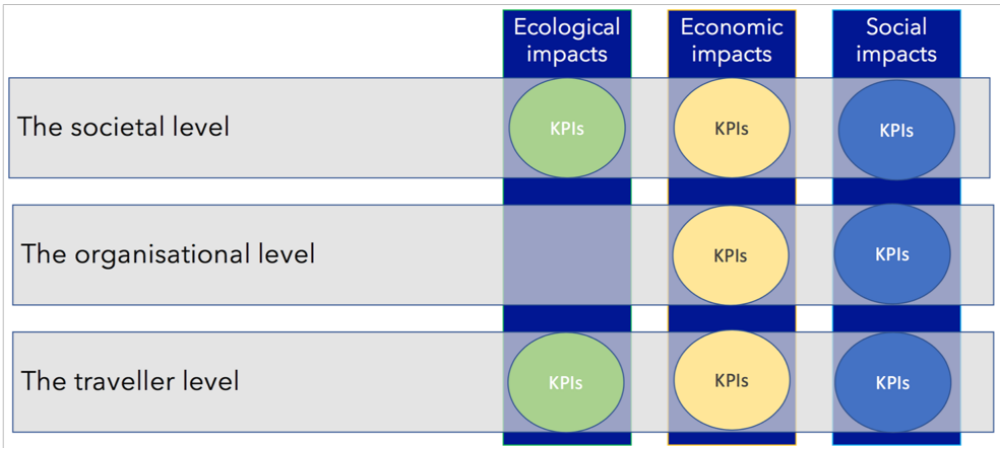


Source: Karlsson et al. (2020).

Another key issue centres around the goals and desired outcomes of MaaS – What is to be achieved and for whom? and How does one measure success? Again, experiencing the complexities of evaluating an integrated mobility service (the UbiGo pilot) and considering the various stakeholder perspectives inspired the development of an evaluation framework. The basic idea was developed in the European project MaaSiFiE and then expanded and formalised in KOMPIS, a Swedish government initiative intending to facilitate MaaS, where one of the five focus areas is effects and consequences. The core evaluation framework measures ecological, economic and social effects on three levels: societal, organisational and individual traveller (see figures 4 and 5 and Karlsson et al., 2019) with a B2C perspective, which offers MaaS directly to individuals and households. (Additional levels and perspectives are being developed to aid in the evaluation of other types of MaaS, e.g. MaaS for employees and MaaS for tenants.) Models

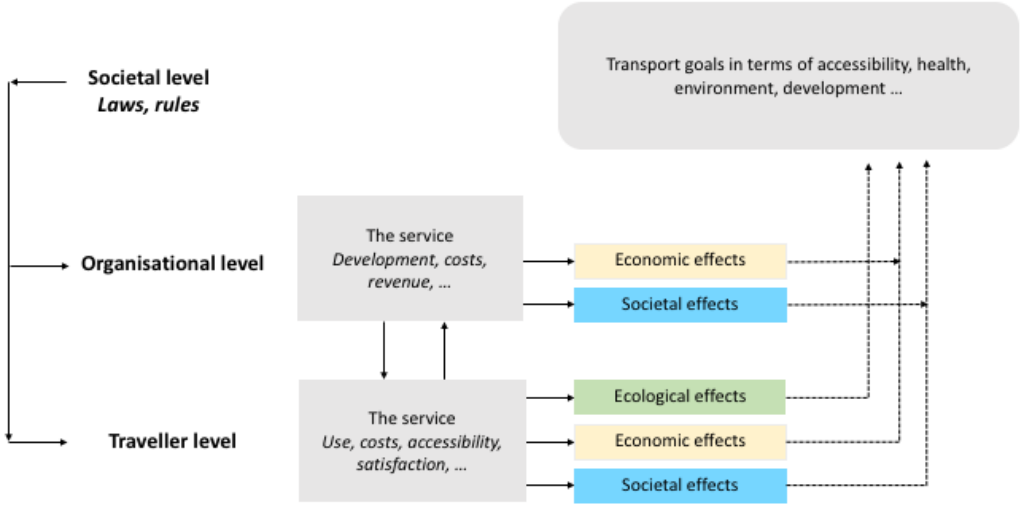
describe the relationships on each level, as well as among levels, as well as the resulting outputs, i.e. a set of KPIs. Data is primarily collected on the organisational and individual traveller levels as it is actions taken on these levels that create effects on the societal level, e.g. the individual choice taken to use a certain mode for a certain trip ultimately results in impacts on society such as energy use and emissions, congestion, costs for the transport system, mode share, land use, etc. The framework also includes data collection instruments to ensure the collection of the data necessary to analyse the KPIs.

Figure 4. Building blocks of the core KOMPIS evaluation framework for mobility services



Source: Karlsson et al. (2019).

Figure 5. Basic model of the core KOMPIS evaluation framework for mobility services



Note: more detailed models of each level have also been developed.

Source: Karlsson et al. (2019).

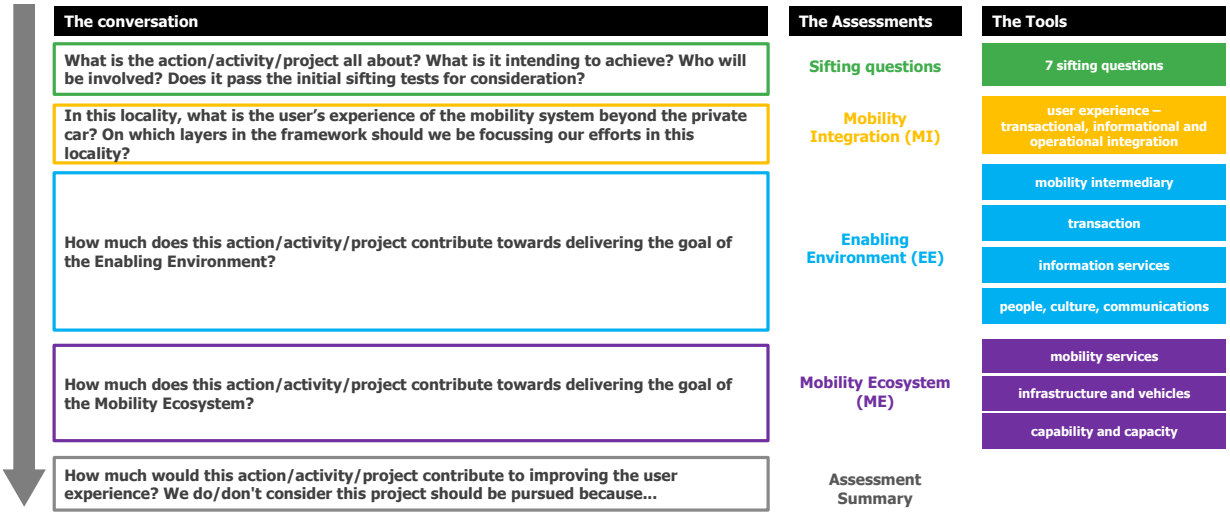
This evaluation framework is open access and available for use, to be coordinated with the work package leader (http://kompis.me/framework). It is also to be used by any pilot or service which has received funding via KOMPIS. The intention of providing this framework is to not only enable more thorough evaluations but more comparable evaluations as well, across both services and time, so as to contribute to a broader understanding of traveller behaviour, sustainability impacts, service design, conflicts and

trade-offs between perspectives and types of sustainability, etc. The more empirical knowledge of different types of services (e.g. service designs, customer segments, business models) in different contexts (e.g. geographical and legislative), and the resulting use and effects, the better researchers and practitioners can understand MaaS in order to guide it towards delivering the intended goals.

One example of an initiative by the public sector, which touches upon several of Smith's sub-activities (Smith, 2020, §8.1) as well as directly addresses the topic of this roundtable – Integrating Public Transport into MaaS – is the recent development of a MaaS and Mobility Assessment Framework by the Queensland (Australia) Department for Transport and Main Roads (TMR), in collaboration with Mott MacDonald and a team of international specialists. The framework is a decision-making tool, designed to be used by the TMR MaaS team to assist in documenting and assessing the contribution of an action, activity or project towards achieving a MaaS and mobility environment consistent with TMR's vision – a single, integrated transport network accessible to everyone. The framework can also be used to refine the design of a project to ensure better alignment of outcomes.

The TMR framework is based on academic theory, e.g. Lyons, Hammond and Mackay's (2019) "hierarchy of user need" and "levels of MaaS integration" (see also Figure 2), and then operationalised using application of principles from Mott MacDonald's proprietary Multi-Criteria Analysis tool INSET. Furthermore, the framework is aligned with the TMR vision, roadmap and preferred business model; structured to ensure a user-centric focus; and designed to accommodate locational specifics, responsive to the diversity of people, places and geography. By ensuring transparency in all elements of the framework, enabled by the narrative assessment approach, the framework is able to accommodate uncertainty and changes in circumstances.

Figure 6. Overall structure and narrative of the Queensland Department for Transport and Main Roads MaaS and Mobility Framework Assessment tool



Source: Queensland Department of Transport and Main Roads (2020).

The framework process is primarily narrative-based, structured to facilitate a participatory and deliberative approach to assessment, and to minimise the risk of "false precision"; quantitative elements are secondary. To provide a brief overview, there are four separate assessment sections (see Figure 6): sifting questions, a user assessment ("mobility integration"), a service assessment ("enabling environment") and a supply assessment ("mobility ecosystem"). Each of these assessments comprises a number of layers for

consideration (e.g. the user experience element is broken down into transactional, informational and operational integration; see Figure 6, right column), and the layers, in turn, consist of attributes (maximum five per layer), i.e. indicators of progress towards success in each layer. Assuming an action/activity/project first passes the sifting questions, completion of the framework process will result in the population of a summary page documenting the key information about how the action will contribute to MaaS and mobility in its targeted geographical area. This can then be used with decision makers to decide whether to proceed with further investment, or which actions/activities/projects to prioritise, in order to achieve the desired MaaS and mobility environment. It is the hope of TMR to be able to promote the use of this tool by others in the future.

Discussion

In reflecting upon why MaaS has not emerged as quickly as envisioned, it is helpful to recognise the complexity of the transport *system*, i.e. adopting a systems approach, looking at the bigger picture, the parts of the system as well as the relationships among the parts, all interacting within a larger context. For example, individual travellers, households, workplaces, communities, public and private transport providers (including MaaS operators), local, regional, national and supranational governments, etc. all interact within this system in which MaaS developments are trying to take form (see Figure 3). Unfortunately, there is a tendency to take a more siloed approach and focus on what the *other* needs to do to act more sustainably without taking into consideration where the barriers to change originate, and without recognising that improvements can, and need to, be made by all. Some barriers may be internal to the individual or organisation (e.g. inertia), but others are external. For example (very simplistically), individuals *just* need to stop driving their cars so much (mode choice by the individual), yet realistic alternatives may not always exist (services from public and private organisations), and car use and parking are not priced to reflect their true costs (public policies). Taking a systems approach to understanding MaaS developments can aid public authorities and actors to better understand which enablers and barriers exist (on all levels), where they originate, and what can potentially be done to minimise them.

It is important remember that a lot is being asked of potential MaaS users, as integrated mobility services can be difficult to grasp, especially while they remain largely unobservable and untestable. Study participants or potential customers must not only 1) try to understand the new service concept in general (MaaS), but they must also 2) try to comprehend a particular manifestation of MaaS with a very specific, detailed service offer (Service X) (and in the case of a theoretical study, a service they cannot observe or test), while they also need to 3) reflect (probably for the first time) on their transport needs and use, 4) estimate how well Service X may or may not match their transport needs and use (also considering that use patterns may change due to using the service), and 5) decide whether or not they are willing to jump in and take the risk of becoming customers at all (and potentially put up with a new service's "growing pains"), let alone how much they would be willing to pay for it. Then, 6) actually undertaking behavioural change (in this case, learning to use a new service as well as potentially reorganising one's daily life and changing one's use of transport), which is a complex and challenging process that is all too easy to disrupt at any and all stages (as discussed in the section "Understanding users and what MaaS can offer"). Also, 7) users of transport rarely make unilateral decisions, but rather coordinate their activities with other

household members, which affects transport needs and behaviours, i.e. if it were not difficult enough, the change process may entail a group of people changing their behaviours. So all in all, users need better support all throughout the innovation-decision process, be it more personal, one-on-one forms of customer support (e.g. choosing or putting together a bundle, coaching sessions on using the app and accessing modes), more flexible offers (e.g. a range of makes and models to test, and modifiable bundles/subscriptions), or even a long enough trial period to potentially get through the change process and establish new habits (probably at least six months to one year, to experience the service under a range of circumstances). The greatest resources directed towards users tend to be in recruiting them, with some, but often fewer, resources placed on supporting users as they learn to use the service and integrate it into their daily lives. Then almost no thought is given to what happens if and when the service or pilot ends (or if the customers discontinue use), and how one can support the users in maintaining their new behaviours. Again, as mentioned above, eliminating barriers is an important strategy, as, if users trial the new service and new behaviours under as realistic conditions as possible, the greater the likelihood that they maintain their new behaviours. Linked to this is creating *trialability* (Strömberg et al., 2016) all along the adoption process, i.e. creating relatively easy and low risk conditions with fewer lock-in effects, particularly when it comes to things people do not normally experiment with unless forced to, such as reorganising their household's transport, giving up a car or changing main modes, etc. Creating a sense of commitment and trust between the users and MaaS provider can also help keep the users engaged, and part of this is the MaaS provider being transparent about what can (and cannot) be expected of their service, particularly in the start-up phase so as to try to mitigate frustration with "growing pains". Curiosity may be enough to draw (some) people in, but such feelings fade over time as one becomes familiar with the new product or service, thus other added values and practicalities must exist to retain customers. Understanding more about the innovation-decision process and users' motives can help public and private organisations (and public authorities) rethink how they can better support users at all stages in the adoption process, including maintaining new behaviours if and when the service ends or after discontinuing use of the service.

Lack of knowledge is a significant barrier at this point in time, as uncertainty begets uncertainty, where not enough is known about any perspective, let alone the user perspective, to have gained any kind of broad understanding of successes and failures; what works where and why (or why not). Right now, there is very limited evidence to either support or contradict the many hopes projected onto MaaS. Not enough different types of pilots and services have existed in enough different contexts; of those that have existed, too many are not thoroughly evaluated; of those that have been evaluated at all, too much information is considered proprietary, or the results are not comparable, or the service (or evaluation) did not take place over a long enough period of time to gain insight on more than short-term impacts. As discussed initially, outcomes could also be related to the type of service (see Figure 1) as the different levels target different types of needs and decisions. Assuming MaaS can successfully emerge in various forms, there currently exists no knowledge on how to guide it towards contributing to greater sustainability (ecological, economic and social). From the user perspective alone, how can one incentivise more sustainable behaviour for groups with very different preconditions? For example, incentivising those who are already, on average, more sustainable in their transport choices (using e.g. public transport and active modes) to not shift to less sustainable choices when joining a MaaS service due to induced demand, while also incentivising those who are, on average, less sustainable (e.g. private car owners and users) to start shifting towards at least shared cars/trips. Not to mention how to integrate or incentivise walking and private biking into MaaS, i.e. behaviours contributing to sustainability and health, but which are not profitable.

Additionally, how will MaaS evolve, when it is not just a novel, new idea (i.e. needing to attract the Early and Late Majorities and Laggards) or when it is scaled, and how will it evolve over time? For example, do

sustainability effects need to become worse before they can become better? Suppose that MaaS creates an induced demand for non-car owners to use shared cars (rentals, carsharing) as a means of gaining access to cars for certain types of trips or circumstances, e.g. encumbered trips or summer vacations. At that point in time, an evaluation might indicate negative sustainability impacts in terms increases in vehicle kilometres and emissions. However, in the longer term, an increasing number of customers of shared cars may achieve a critical mass, leading to an expansion of such services beyond niche markets such as city centres. Then, higher levels of observability (Rogers, 2003) and more comprehensive geographic coverage could facilitate a shift in the minds of private car owners towards shared cars in terms of offering a more comprehensive alternative to ownership, thus increasing the number of people willing to sell their cars. An evaluation at this point could then indicate positive sustainability impacts in terms of reductions in vehicle kilometres and emissions, reductions in parking infrastructure, etc. A period of evolution may be necessary, but how long is it feasible to wait? And at what point(s) is modifying various public policies most helpful and/or necessary? So much remains to be explored, let alone learned. But in general, when it comes to facilitating an increase in knowledge, public actors can and need to play a larger role, both in terms of engaging in pilot and service activities (e.g. running, participating in, funding) which may also include policy experimentation, and in demanding thorough evaluations, the results of which (*successes and failures)* are shared with the wider community in order to learn lessons from each other about what works where and why (or why not). Furthermore, the development of evaluation frameworks like KOMPIS can not only support what is a complicated process even for experts, but can also help public authorities lay the foundations in terms of understanding the relationships between the different perspectives (and that there exist conflicts and trade-offs among them), as well as in terms of establishing goals or desired outcomes (from the viewpoints of the different perspectives) in advance of the evaluation (if not in advance of the design of the service itself).

Another potential point of myopia is the rhetoric on public transport as the backbone of MaaS, at least if one focuses on public transport as mass transit. This may limit the imagination to MaaS as an urban phenomenon where many different modes already exist, or where additional modes act as add-ons to facilitate first- and last-mile trips. But as pointed out at the start of this paper, a focus on developing single modes (even public transport) has not led to the desired changes in transport. In all actuality, throughout much of the world, even in urban areas, the private/non-shared car is the backbone of transport. Even many so-called transport innovations have largely entailed prolonging the status quo (e.g. shifting from a fossil-fuelled private car to an electric private car, or in the future, an automated car, which does not address issues such as congestion if capacity and utilisation rates are not improved). If one instead takes a broader perspective on *collective transport* (i.e. how can communities in different contexts collectively meet their transport needs) and the spectrum of potential services, there are deeper questions which can be asked. For example, how can the public and private sectors work with communities to best ensure the availability of a range of mobility options (public, private and peer-to-peer), appropriate to the local context, that complement each other so as to offer a relatively comprehensive and reliable alternative to private/non-shared car ownership and use? How can one make using a more sustainable mix of the options (e.g. more active modes, more shared modes in terms of both utilisation and occupancy rates) relatively more attractive, while making the use of private/non-shared cars relatively less attractive?

Imagine the various local geographic contexts, urban, to suburban, peripheral, or rural, while the local (traditional) public transport context can range from a strong mass transit offer as the backbone with other mobility services acting more as add-ons, to a weaker public offer where other mobility services serve more of a strengthening role by providing first- and last-mile access, to a very weak to non-existent public offer. Consider for example a range of potential mobility and related services including private cars and bicycles (and walking), fixed public transport, demand-responsive public transport, special transport

services, ridesharing, car rental/sharing, specialised vehicle rental/sharing (e.g. moving trucks, trailers), electric and cargo bike rental/sharing, e-moped/e-scooter rental/sharing, home deliveries, transporting bulky goods (e.g. trips to the recycling centre), mobility hubs, etc. Which subset would need to exist a given local context so as to create a relatively comprehensive and reliable service offer; how can this be actualised into attractive and viable offers; and how can relatively more sustainable choices be incentivised? In more urban areas, the larger potential customer base can be a motive to offer relatively more of these modes on a commercial basis, whereas in more rural areas, there will need to be a greater emphasis on offering relatively more of these services on a peer-to-peer basis, where the peers could be individuals or local organisations. In terms of demand and incentivising sustainable behaviours, in more urban areas, the more sustainable yet reliable mix of options will entail a large share of trips via fixed public transport (the proverbial backbone) and active modes, and a smaller share by other types of mobility services. But in more rural areas, the more sustainable yet reliable mix of options will differ as services will be more susceptible to disruption due to the sheer fact that there are fewer people to create a critical mass of users for any given service (and reliability is a central factor in the user's choice process so as to be able to perform activities in a timely manner). In such contexts, the relative reliability of the private/non-shared car (sitting outside one's door whenever one needs it) will surely enforce its continued use as a form of mobility insurance. Nonetheless, in all geographical contexts, public authorities, whether they do it proactively or by conducting business as usual, set conditions and requirements for the operators (public or private) to both offer services and incentivise (or not) desired behaviours (not to mention the public authorities' direct influence on incentivising/deterring behaviours via various policies and regulations).

There is much to learn about MaaS developments and much that the public sector can do to more strongly engage in MaaS developments, from involvement in pilots and services (including service design), to setting conditions for operations, to demanding data and evaluations, to adapting or experimenting with public policies; the list goes on. This discussion paper has attempted to utilise findings from the user perspective, in an interplay with (mainly) the service perspective, to illustrate their interdependencies and the importance of service design, but also to try to paint the bigger picture of MaaS. This to help the reader understand some of the complexities of MaaS, embedded in the larger system that is transport, so as to facilitate moving forward with eyes wide open. Just as any good product or service design requires planning, testing, and multiple iterations to "get it right", so too will achieving MaaS in particular, or a more sustainable transport system in general; thus, all the more important to learn from each other.

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International Transport Forum

Piecing Together the Puzzle

Mobility as a Service from the User and Service Design Perspectives

Many regions are seeking to improve mobility choices for citizens, both in congested city settings and poorly connected peripheral communities. Mobility as a Service (MaaS) is increasingly presented as a possible solution, yet beyond pilot level there are no examples to date of what a successful implementation of MaaS might look like. This paper reviews pilot studies and ongoing research into the user perspective on MaaS and the lessons learned thus far.

All resources from the Roundtable on Integrating Public Transport into Mobility as a Service Roundtable are available at: www.itf-oecd.org/integrating-public-transport-mobility-service-maas-roundtable.

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