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**Understanding MaaS: Past, Present and
Future**

By

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Introduction

Daily references to the changing landscape in the provision of passenger transport services is made in the transport literature, including grey material. Mobility as a Service (MaaS) is the acronym which appears to have caught the imagination of technology providers with promises of a new era of passenger transport whereby assets need not be owned and services can be bought at the point of need. It is the technological developments which have spearheaded the new understanding of MaaS.

MaaS has evolved into a concept that integrates public and private transport services to provide one-stop access through a common interface. MaaS is at the centre of the popular view on future collaborative and connected mobility. For transport policy, MaaS is seen as a way to reduce car traffic, and its negative externalities, by enabling citizens to satisfy their mobility needs without having to own assets such as automobiles, either conventional or (in the future) self-driving. MaaS also opens new choices for non-car owning citizens who previously had limited transport options, making some of them socially excluded. Whilst definitions vary, the concept of MaaS has several dimensions: in the form of a smart app and in real-time, it provides mobility services using multimodal options, through a sophisticated journey planner that provides the user with multiple customised options and offers the opportunity for payment either at the point of use or with a pre-purchased mobility bundle. This single platform is envisaged to eventually be transferable around the world from city to city and region to region and also to remain pervasive to the user by working and monitoring the journey in real-time and providing options for recovery in the case of disruption, and with an aspiration to support public equity objectives.

MaaS has also received considerable attention in recent years from decision-makers (for instance, the Finnish government has implemented new transport regulations intended to facilitate MaaS developments) and practitioners (examples of MaaS start-ups include MaaS Global in Finland, EC2B in Sweden and Moovel in Germany) as well as researchers (e.g., Hensher and Mulley (2019) Hensher, 2017; Jittrapirom, 2017; Sochor et al., 2016; Wong et al., 2019; Mulley, 2017). Still, the knowledge of MaaS is nascent, trials for the most part have not been thoroughly evaluated and the evidence for the mobility and societal benefits of MaaS have yet to be confirmed.

The paper is structured as follows. The next section provides the literature context that underpins the part of the title of this paper relating to the 'Past'. This is followed by a section detailing the present in terms of a current MaaS trial in Sydney, New South Wales, designed to provide another 'data point' in our current understanding of MaaS. The penultimate section looks to the future and the challenges ahead by identifying some key questions critical to the development of MaaS. The final section concludes.

Literature context

MaaS publications began in the realm of the grey literature before being joined by contributions from the scientific community. This reflects the nature of academia with the long lead time of research and delays in the peer review and publication process. From around 2016, MaaS grew in prominence across the West, with a rapid fire of publications from special-interest media (The Economist, 2016), consultancies (Atkins, 2016b, Atkins, 2016a, Hazel, 2017), think tanks (Transport Systems Catapult, 2016, Dotter, 2016, RethinkX, 2017), trade associations (TravelSpirit, 2017), transport suppliers (Cubic, 2016), transport operators and transport regulators. However, many reports by businesses and industry groups are generally based around expert opinion (rather than any empirical research) and often driven by commercial intent.

The scholarly knowledge base on MaaS has generally developed following this initial explosion of popular press articles and reports. Whilst we can point to a couple of academic theses (Heikkilä, 2014,

Rantasila, 2015) which predate the grey literature cited above, academic publications generally emerged around 2017 with the Thredbo Series (Thredbo 15, Workshop 7)¹ addressing the issue of MaaS for the first time and with the first of the ICoMaaS conferences. This literature context looks first to the taxonomy of MaaS, briefly at studies which have examined customer demand, what has been learnt about what businesses are prepared to supply as a way of characterising the state-of-the-art.

The taxonomy of MaaS

To date, MaaS as described above has been primarily a European concept. In Australia, MaaS has developed to have the same interpretation (Ho et al., 2018; Hensher, 2017; Mulley et al., 2019). In India, too, MaaS seems to be understood as a concept with at least academics considering its applicability. However, in the US, the underpinning of MaaS in terms of providing a service rather than the product of a transport asset which is personally owned is more captured by the growth of Transport Network Companies (TNCs) which, usually through apps, matches passengers with vehicles providing the mobility service. “Transport as a Service” is the phrase which characterises the US offers in this field. The US Department of Transportation has also promoted the term “Mobility on Demand” with an emphasis on commodified transportation services, as well as system management (Shaheen et al., 2017; Cohen, 2018) and is thus quite different to MaaS. In the People’s Republic of China (PRC), there are a proliferation of apps offering similar services to the TNCs yet in Hong Kong, which perhaps has the only public transport system not requiring subsidy, there is next to no interest in MaaS nor of its constituent mobility services such as bike share (which maybe more to do with local topology). There appears to be little evidence yet of the concept developing in Latin America in any formal manner although there is a long history of informal shared, flexible transport solutions which could provide a useful basis for development taking account the widespread available of smartphones.

Given that the MaaS concept is centred on providing a holistic experience, the approaches to taxonomy based on the level of integration makes sense, as opposed to defining MaaS by reference to its attributes which are more of a feature of customer experience rather than MaaS delivery. Lyons et al. (2019) proposes four aspects of integration which are necessary: (i) operational integration, meaning that interchange penalties are low and the door-to-door journey experience ‘seamless’; (ii) informational integration, referring to a one-stop interface for journey planning and execution information for all available modes; (iii) transactional integration, linked to one payment platform for booking and ticketing; and (iv) cognitive user effort, which encapsulates the above three aspects such that use of MaaS becomes comparable to or better than that of private car reliance. The degree of operational, informational and transactional integration determines the level of cognitive user effort required on the part of the traveller. Lyons et al. (2019) puts forward five ‘Levels of MaaS Integration (LMI) taxonomy’ which categorises MaaS systems according to the amount of cognitive effort required by the end user to navigate. A variation of defining MaaS by reference to its level of integration is provided by Sochor et al. (2018) which recognises four levels of integration that are information, payment, mobility packages and government policy. Figure 1 compares the hierarchies of Lyons et al (2019) and Sochor et al (2018).

¹ <https://thredbo-conference-series.org/papers/thredbo15/>

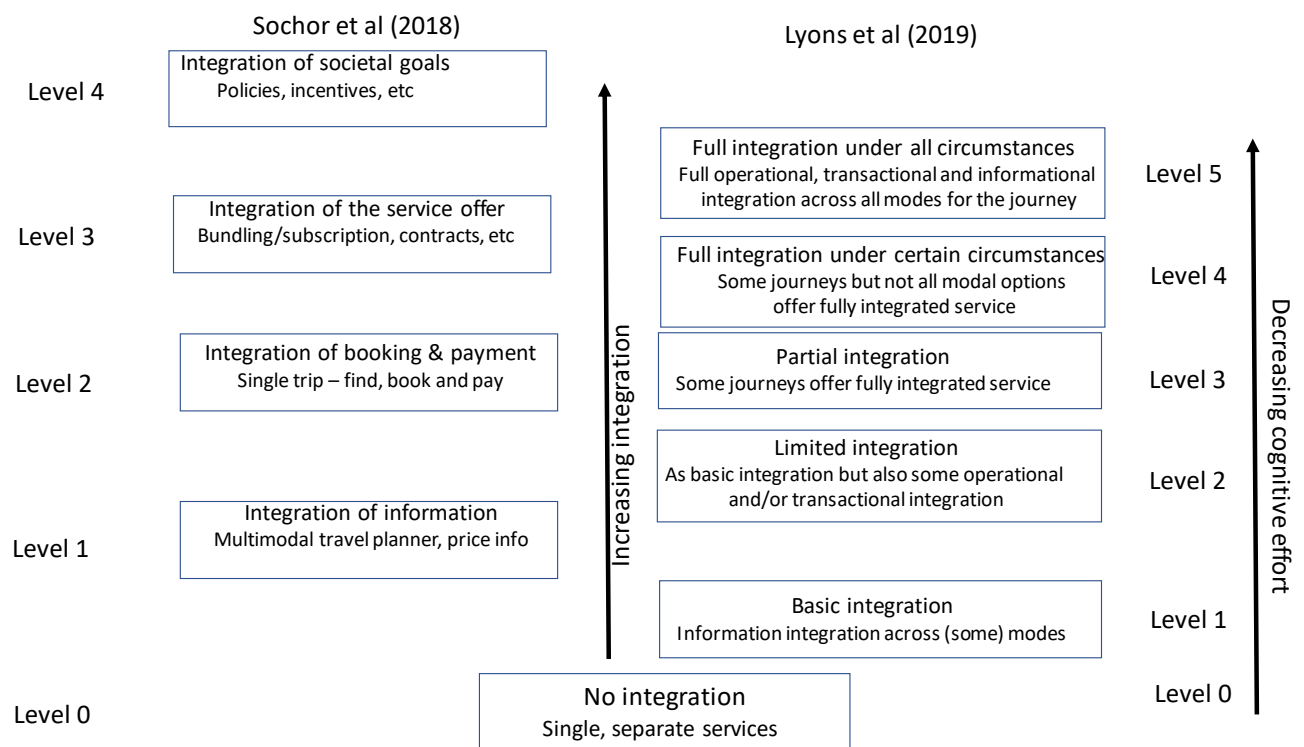


Figure 1. A Classification of MaaS Integration, adapted from Sochor et al. (2018) and Lyons et al. (2019)

MaaS Services from a demand perspective

A major theoretical contribution around the design and implementation of MaaS may be related to the *three Bs* “budgets, bundles and brokers” initially proposed in Hensher (2017: 91). Bundles relate to mobility packages which customers purchase, granting them a defined volume of access to each included mode (usually quantified by kilometres, hours or a percentage discount). Stated choice studies on end user preferences for bundled mobility products have thus far been conducted in a range of locales as a way of revealing potential user preferences. Market testing of MaaS is related to the budgets concept in terms of the need to elucidate the preferences of all stakeholders including demanders and suppliers in the MaaS supply chain. Far less work has to date been undertaken on the supply-side, particularly around potential business models and the likely emergence of mobility brokers (also known as aggregators) which bring together specialised businesses and value-add by offering that integrative function. Brokers form the conduit for connecting demanders of transport service and suppliers of the transport asset/capacity by facilitating the delivery of physical transportation. Evidently, bundles exist as a demand phenomenon and brokers as a service delivery or supply-side issue. Budgets is cross-cutting and relates to how demand and supply ought to be considered by way of the preferences (including financial preference or willingness-to-pay) of the stakeholders.

One of the greatest promises of MaaS is the immense value add provided by integrated information interface. Often, the step-change in information provision by means of a digital application and one-stop payment functionality is hailed as a panacea for a seamless travel experience for the end user. However, the MaaS experience is only as good as the physical services being provided within the application. One important issue is that the overwhelming majority of MaaS implementation to date have been commercial in nature without any form of evaluation conducted to obtain the information which interests researchers. There are two main exceptions to this, from the UbiGo trial in Gothenburg and Whim scheme in Helsinki. Although a small-scale pilot which ran for 6 months, UbiGo shows how MaaS makes it easier for subscribers to use several complementary transport services (Karlsson et al.,

2016; Sochor et al., 2016). In the case of Whim, an ex-post analysis of the Helsinki experience over one year was undertaken by the consultancy Ramboll (2019). This lacks the academic rigor of the UbiGo evaluation and provides little in the essential detail of how many subscribers and frequency of use but does suggest that subscriptions were the preferred mode of engagement by customers. This underscores the reality of studying the market and the need to use stated preference studies given the lack of information from commercial MaaS pilots.

In the past few years, a number of different contributions have been made in terms of understanding the market for MaaS from stated preference or choice experiments, conducted in Sydney, Australia (Ho et al., 2018), London (Matyas and Kamargianni, 2017), Australia (Vij et al., 2018), Zurich (Guidon et al., Forthcoming) and Newcastle upon Tyne, UK (Ho et al., 2019). Each study offers unique insights according to the design of their survey instrument (representative of the hypothetical MaaS package being offered), as well as modelling approach and respondent sample. Ho et al. (2018) found that infrequent car users might be the most interested in a bundled approach of MaaS and that public transport offerings in Sydney were not at the core of respondents' MaaS plans with the main message being that those who were only private car users or solely public transport users tend to have less interest at present than those already undertaking multimodal journeys. The study found, on average, about 47% of respondents (n=252) identifying they would 'consider' subscribing to a MaaS plan (a number uncannily similar to that found in (Vij et al., 2018)). What is most interesting is that Vij et al. (2018) found pay-as-you-go to be more popular than subscription-based MaaS models, as compared with Ho et al. (2018) where the reverse was found to be true. Such findings are highly dependent on how modes are bundled and the discounts designed within each offering. More discussion will follow in the Section describing the MaaS trial in Sydney.

Matyas and Kamargianni (2017) market tested mobility packages to London commuters using stated choice techniques informed by a smartphone-based travel survey of existing behaviour. Although this research was limited by its small sample size (n=80 for full survey completion) and level of analysis, subsequent waves should build on this preliminary data, using more advanced models to investigate market segmentation, inter alia. There is also value in conducting such demand analysis in the Australian context, which brings with it unique opportunities and challenges in terms of urban form, a more embedded car culture, and a less mature market for on demand and shared mobility. Finally, Guidon et al. (Forthcoming) identify that a number of modes including public transport, car sharing and park and ride services are more highly rated by respondents when in bundles as compared to when they are not. As a corollary, this suggests that bundles should exclude some lower valued modes and offer them in a PAYG format.

MaaS services – a supply perspective

Supply-side issues have to date received less attention than demand-side issues in the MaaS literature. This is due to the genesis of MaaS which has its roots in promising better service for the customer, as well as the difficulty in conducting empirical research on business and government. Much of present research on the supplier interface have been confined to exploratory work examining the desire for business and government to collaborate (Sarasini et al., 2017, Kamargianni and Matyas, 2017), partnerships between incumbent public transport operators and TNCs (Boone et al., 2018), barriers to greater collaboration and innovation in business (Smith et al., 2018), as well as the role of government in MaaS business structures (Jittrapirom et al., 2018). Thus far, no empirical research on the design and structure of MaaS business models have been forthcoming, to the best understanding of the authors.

Identifying a suitable MaaS business model is perhaps the single most critical supply-side issue. Indeed, business models are identified in Smith and Hensher (2019) as one of nine essential areas of innovation for MaaS (the others being terminology, objectives, rules, technologies, modes, alternatives, partnerships and diffusion). Innovation is required since the design and

institutionalisation of a MaaS business model is particularly demanding given that innovations occur outside the exclusive control of traditional firm boundaries (De Reuver et al., 2013).

The mobility broker, the *third B* (along with bundles and budget) in Hensher (2017), also known as an aggregator or intermediary, functions as a new agent which brings together specialised businesses like mode-specific operators and non-mobility providers required to deliver an integrated MaaS offering for the customer. Kamargianni and Matyas (2017) propose that the mobility broker will need to bring together a business ecosystem of seven actors—transport operators (including mobility service providers like parking operators), data providers, technology and platform providers, information and communication technology infrastructure, insurance companies, regulatory organisations and universities / research institutions.

Despite some literature looking at the supply side, more information is needed in understanding what potential stakeholders in this space might be looking for and what they might supply or invest in. Wong et al (2018) explore the views of the business community (broadly defined) to the different possibilities for MaaS business models. The evidence comes from a stated choice empirical study of business leaders representing 202 organisations across 28 countries (covering most developed economies). Wong et al. (2018) describes the creation of these mobility contracts (based on stakeholder interviews) and design of the experiment in more detail. The results of the study are explored further in Wong et al. (2019). The survey identified different ways in which businesses could potentially participate in the MaaS model—namely by investing in or supplying in to the new MaaS business. The difference here lies between contributing physical assets and assets in-kind, or becoming solely a financial shareholder in the broker/aggregator. It is generally more intuitive for mode-specific operators to supply (given their existing assets) and non-mobility providers to invest (since they do not operate transport services). Supplying physical assets was about 25% more popular than investing. Segmenting by organisation type, non-mobility providers overwhelmingly desired to supply technology assets, representing 73% of instances. For mode-specific operators, the most popular asset types with which to supply were vehicles (87%), personnel (77%), and bricks and mortar (62%) assets. Bricks and mortar assets cover infrastructure assets like depots, stabling facilities, as well as public transport stops and stations.

The MaaS Trial in Sydney, NSW, Australia

The literature review has contextualised the pilot of MaaS in Sydney, New South Wales, Australia which is introduced in this section. The Institute of Transport and Logistics Studies at The University of Sydney with funding support from the IMOVE Co-operative Research Centre, together with Insurance Australia Group (IAG) and Skedgo (a technology provider) are collaborating to design, undertake and assess the impact of a real market trial of MaaS in Sydney. It is the first trial in Australia and the first substantial trial which has a research partner as part of the collaborative effort.

The global literature has been used to inform the parameters of the trial. Importantly, for a decision about what sort of offerings should be made to potential MaaS participants, a recent report by ARUP² about the benefits of payment models suggested a possible push away from rigid subscription-based products (“High level MaaS”) towards more flexible variations on PAYG, which is the fourth approach in the schematic progression (“Low level MaaS”), depicted in Figure 2. In interactive workshops in Ireland and Australia held by ARUP, key participants noted that *flexible pay as you go services continued to increase across modes, whereas subscription-based products in their current format were reducing in popularity.*

² See <https://www.arup.com/perspectives/publications/research/section/urban-mobility-in-the-smart-city-age>

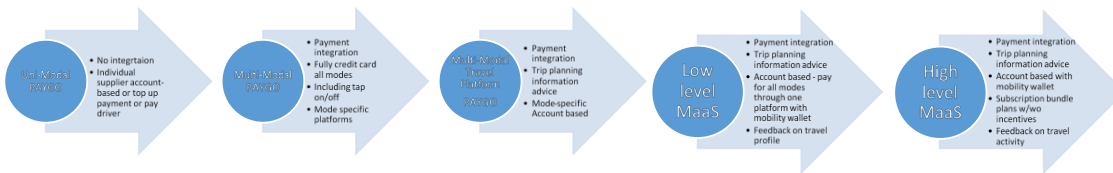


Figure 2: Progression of mobility services towards ‘High level MaaS’

Hensher (2019) unpublished

The global literature has also been scrutinised to determine what government policymakers (currently) see as the best benefits of MaaS. The premise of the Sydney trial was that policymakers would be interested in a reduction in car ownership; however, the recent ARUP report found that reduced car ownership was seen as less important than other factors for policymakers. It was considered to be a tertiary outcome or resultant symptom of more important outcomes such as more convenient access to multimodality and increased public transport patronage. Given that reduced car ownership is seen as a primary reason for the development of a MaaS ecosystem in other jurisdictions, such as Sweden and Finland where MaaS is relatively more mature (although in many ways still in the very early days of assessment)³, this development is an important factor for policy makers. The topics that generated most excitement from policymakers, as reported by the ARUP workshops, were increasing patronage on public transport and improving the ease of multi-modal travel. In the Sydney trial, an intention was to structure the MaaS offering as a way of reducing private car *usage*: hence the trial monitors not only changes on public transport use but also changes to car trips.

There were three main motivations for the Sydney trial. As the literature context above shows, digital devices and connectivity open new possibilities to improve transport mobility services and information for users on choices suggesting that MaaS might hold potential to improve and/or complement traditional public transport. Second, as there is only so much information that can be gained from stated preference studies, there is a need to see how real people react to different mode mixes and subscription plans. Finally, to answer two questions for which there is, as yet, no clear answer: whether PAYG is preferable to subscription bundles and whether the broker should be the government or a private stakeholder.

The objectives of the trial are to explore appropriate transport service mixes and subscription plans for early adopters of MaaS; to generate first-hand knowledge of actual MaaS experiences; to assess the readiness of the current public and private transport mix in Sydney to support MaaS – cognisant of the way in which Australia provides a more car centred context than mainland Europe; to advance the understanding of user uptake and willingness-to-pay for MaaS; and to test the ability to influence travel behaviour through introducing MaaS subscriptions. A final objective was to ensure that rigorous evaluation was undertaken so as to document the experience in designing, planning and undertaking a MaaS trial.

The trial is still at an early stage but respondents have been sought from the IAG workforce, comprising over 8000 employees. These have been selected through response to an online survey. The online survey resulted in 222 respondents, of which 185 respondents had an iPhone 5S or later version, as these operate the eligible operating system for this trial. The analysis of the data provides a profile of travel activity and geographical residential location of respondents. The main findings clearly show that there is some amount of multi-modal travel activity, with the highest number of iPhone owners using a mix of public transport and car, followed by a combination of public transport, car and

³ Hensher, D.A., Mulley, C., Ho, C., Nelson, J., Smith, G. and Wong, Y. *Understanding Mobility as a Service (MaaS) - Past, Present and Future*. A book in progress written by the ITLS team (9 Chapters), planned completion date December 2019, to be published by Elsevier.

taxi/Uber. There are a reasonable number of respondents who use only public transport as well as mix of public transport, car share and taxi.

Despite the relatively small sample size, the findings show a good spread of modal use including multi-modal activity which aligns well with the potential interest in MaaS. Although we have very few car only respondents, an important objective is to encourage reduction in car use through MaaS bundle designs that offer varying financial incentives (aligned to specific objectives) as well as other desirable key performance indicators such as reduced travel times, reduced emissions and health benefits (more walking). The MaaS process provides a mechanism to inform participants in a way that can support changed travel practices that accord with the set of objectives that garner societal value as well as personal benefit.

The survey showed respondents came from throughout the Sydney area. The following map shows the home location of respondents against the railway lines – a major component of the public transport network in Sydney.

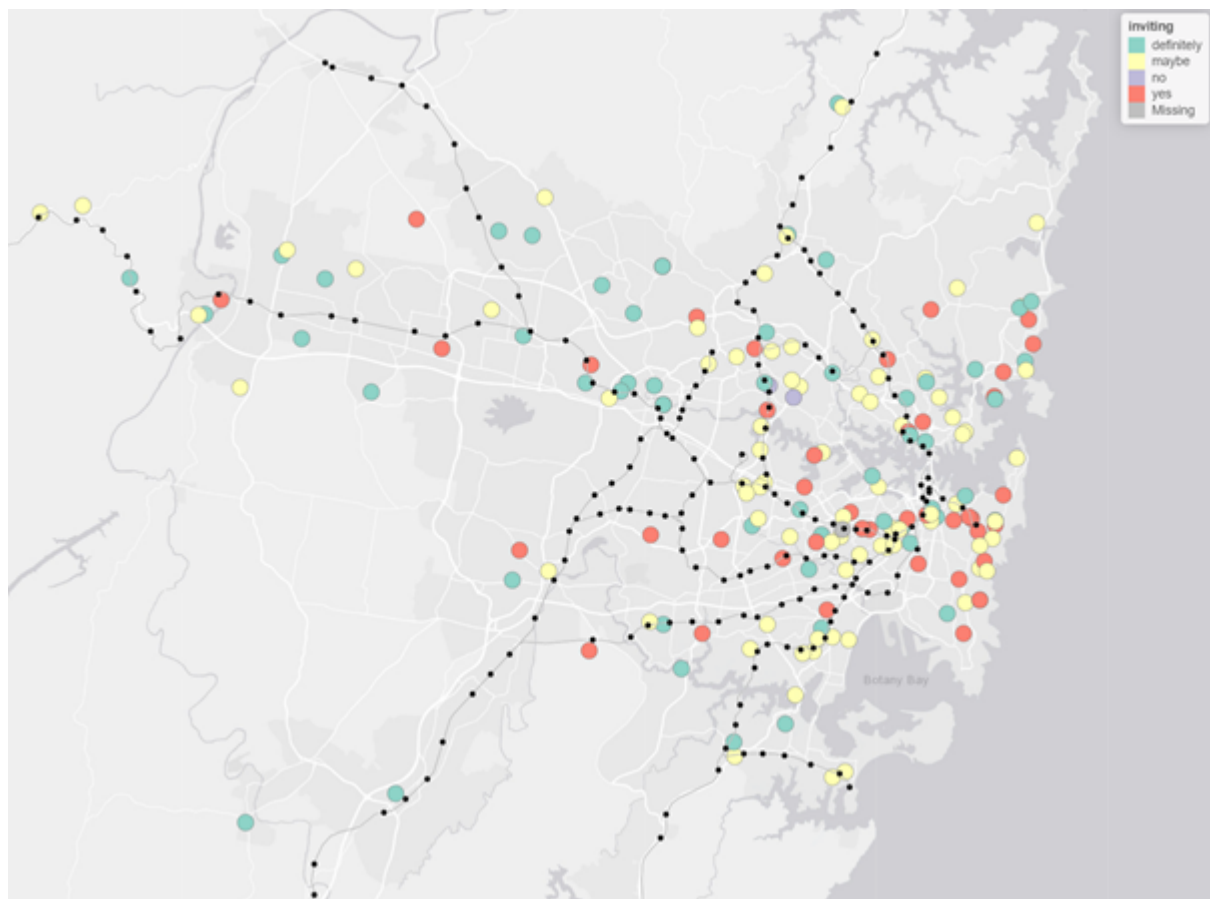


Figure 3: Home location of respondents against the train lines: pre-trial survey

A set of questions at the end of the survey, after watching a video on the meaning of MaaS, sought interest in knowing more about MaaS which is designed to start the information journey in converting interest into joining as a participant in the MaaS trial. A majority of respondents to the pre-trial survey show a great level of interest in MaaS and its features (such as an integrated app which does journey planning, billing, and offers an option to purchase mobility bundles). This is summarised in Figure 3.

Based on the respondents' interests in MaaS, they were classified into four groups for recruiting to the MaaS trial using criteria that a participant must have an eligible iPhone; and that participants will be chosen from a ranked list of respondents, where the ranking is based on total scores they gave to the MaaS features in the final section of the survey so that those respondents most interested in MaaS are chosen first.

Month 1 of the trial (November 2019) has been designed as a PAYGO period in which the travel behaviour of trial participants are monitored through the *Tripi* app, developed by SkedGo and the trial team as part of the project. The purpose here is to develop a database of travel activity of participants. Alongside this, a supplementary online survey and tracking devices fitted to participant's cars has been developed to obtain data not available through the App through the use of the Safer Journeys service developed by IAG⁴ (e.g., car kms, number of car trips by time of day and weekday vs weekend, parking costs, access and egress modes to main mode). This information allows groupings of classes of participants to aid Bundle design, based on the key objectives of reducing car use, reducing emissions and a greater take up of sustainable modes.

The bundles are designed to be attractive through offering different levels of discount for different modes and so a key issue is to estimate the likely subsidy required per bundle, given the financial limit of the project. The trial is now at the stage where bundles are to be offered to participants to see how they may appeal and to support behavioural switching from the month 1 PAYGO. Throughout Month 2, and subsequent months up to Month 6, qualitative research will be undertaken with subsets of participants to identify positive and negative issues and to start to learn about behavioural change.

Future Challenges

This final section posits some questions critical to the development of MaaS. They can be seen as a set of future challenges that need interaction between operator (both mode-specific and non-mobility), policymakers and government and scientific research to resolve.

Will MaaS be too expensive to deliver beyond high density areas?

The clear majority of the MaaS schemes that have been piloted to date are urban based – including the trial in Sydney. This prompts the question as to whether MaaS will ever be able to grow beyond the urban areas? If MaaS is to become a predominantly urban phenomenon, will it be viable only in high density urban areas such as are seen in Europe?

Who are the key stakeholders in the MaaS ecosystem?

Candidates for this role, either separately or in combination include Government, local authority, private sector, or transport operator. Experience, particularly in the UK context to date, has shown that each of these roles need to be defined and allocated. This leads to the all-important question as to how the governance of MaaS should be structured and whether this is context specific and institutional framework dependent.

What are the potential problem areas for MaaS?

The history of “failed” MaaS pilot schemes would suggest that there are problems to be overcome. The UK Parliament Transport Select Committee (2018) in identifying the prospects for further development of MaaS have identified a number of potential problems or disadvantages of MaaS that

⁴ Safer Journeys is a new service initiative being developed by IAG that uses telematics technology to protect customers on the road. The first release of this service helps customers by using in-car telematics technology to immediately detect if a customer encounters a road accident (minor or major). This will help the MaaS pilot to gain more insight into how MaaS trial participants behave with their existing personal vehicles while using the MaaS trial service.

should be overcome, principally: an increase in the use of taxis and private hire vehicles (as with the arrival of ride-hailing apps) at the expense of other modes is not necessarily desirable and may contribute to worsening traffic congestion; MaaS may contribute to worsening digital and social exclusion, while recognising the possibility to encourage first and last mile services and one way trips; and MaaS solutions being available in some places and not others (i.e. boundary limitations).

Is MaaS capable of making it to mainstream?

The major question is what underpins the concept of MaaS and whether or not it will make it beyond the pilot or limited operation to what might be regarded as mainstream. There is still limited clarity as to how MaaS will develop and whether or not maturity in MaaS will yield the benefits it promises and which are captured in the level 4 integration of the Sochor et al. (2018) vision of the integration of societal goals (see Figure 1).

What does success look like for MaaS?

It is still early in the development of MaaS. One of the limiting factors to date is the paucity of detailed evaluation studies of MaaS trials (with UbiGo being the exception). The trial in Sydney, as a car orientated city, will provide another data point as to what might be counted as success. The need to achieve critical mass for MaaS schemes is one obvious measure of success and learning from the on-going experiences of Whim in Helsinki (and the relative lack of success of Whim in Birmingham) is important in this respect. The MaaS operators will also have a view on what constitutes a successful outcome for MaaS.

Are the business models still too much in their infancy?

Big questions and therefore debate surround how MaaS will be organised. The MaaS vision is predicated on public transport offerings being at the centre of the MaaS bundle. If this is the case, what are the organisational challenges for government in terms of legislation and governance? Public transport is subsidised – sometimes heavily – so how will the governance be able to provide this subsidy in what is being promoted as primarily a market response to user demand? This leads to the question as to how will the supply side emerge to provide what is demanded by users?

Opportunity or threat from autonomous vehicles?

Finally, there is the issue of technology and autonomous vehicles where the unknown is bigger than MaaS - how autonomous vehicles (AVs) will affect our landscape more generally. The implications of AVs for the development and sustainability of MaaS has received less attention although it is widely expected that AVs will have the potential for greater door-to-door solutions (and a likely reduction in active travel) which is something that can also be expected of MaaS. A study conducted by Woldeamanuel and Nguyen (2018) to understand perceptions of millennials and non-millennials regarding AVs, found that a greater number of millennials (41%) believe that traffic congestion reduction is likely to happen, informed or otherwise, compared to non-millennials (23%). This is the cohort that will determine the future role of AVs within MaaS schemes.

Conclusions

This paper has identified salient points in the development of MaaS and framed this as the context of past, present and future developments. Crucial to the current debate is the need to understand MaaS services from both a demand and supply perspective. The discussion around the MaaS trial in Sydney is offered as another 'data point' in our current understanding of MaaS. The trial offers a further opportunity to generate first-hand knowledge of actual MaaS experiences and will test the ability to influence travel behaviour through introducing MaaS subscriptions. Addressing whether PAYG is preferable to subscription bundles and whether the broker should be the government, or a private

stakeholder will be important contributions to future policy making and a successful trial outcome will go some way towards addressing the future challenges identified in this paper.

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