MaaS (Mobility as a Service) market futures explored

Marcus Enoch \textsuperscript{a,b,*}, Stephen Potter \textsuperscript{b}

\textsuperscript{a} School of Architecture Building and Civil Engineering, Loughborough University, Loughborough, LE11 3TU, UK
\textsuperscript{b} School of Engineering and Innovation, The Open University, Milton Keynes, MK7 6AA, UK

\textbf{ARTICLE INFO}

\textbf{Keywords:}
Mobility as a service (MaaS)
Product service system (PSS)
Public transit
Market scenarios
Future transport systems
Transport foresight

\textbf{ABSTRACT}

The term Mobility as a Service (MaaS) refers to a seamless, single interface, fully integrated and customised transport service. Whilst the technological barriers to implementing MaaS are steadily being overcome, less is known about how the MaaS eco-system might evolve. This paper unpicks the MaaS concept in light of broader societal trends to suggest how it could evolve and offers insights for practitioners and policy makers. The paper draws on relevant literature, together with discussions with stakeholders, to better understand how MaaS has emerged. It then constructs four future MaaS market scenarios and identifies implications. It is concluded that current expectations of how the MaaS concept may evolve are limited in their understanding of how the transport system could change should MaaS be adopted on a wide scale. The major challenges for policy makers will likely relate to balancing the promised benefits offered with issues such as safety (including bio-safety in our post-Covid-19 world), data security and privacy, equity and the threat of dominant suppliers distorting the marketplace. Together, these insights suggest that the MaaS reality may be messy and difficult to manage, and that future transport systems might look very different to now.

1. Introduction

Mobility as a Service (MaaS) systems aim to match the mobility requirements of customers for each trip they make to a range of potential transport service options. This concept is powerful because it directly connects travellers with a range of transport providers in a dynamic marketplace where the supply of transport can be considerably more responsive to user needs than is the current case. The technology for MaaS is developing rapidly, but what is less well understood is how MaaS operators and the operators of specific functions might work to deliver MaaS, and how this might impact on the wider transport system.

The aim of this paper, therefore, is to unpick the Mobility as a Service concept in the light of broader societal trends to indicate how it may evolve in the future, thus providing insights for practitioners and policy makers.

The research topic concerns the seemingly narrowly focused understanding of what is the MaaS concept, and how the sector might develop in the future. In particular it contains relevant lessons for the transport policy responses needed in a post Covid-19 world, and a context where transport strategies require a doubling of public transport use by 2030 in order to limit global warming to 1.5 °C (ITWF/C40 Cities Leadership Group, 2021).

The paper is based on a review of academic and grey literature, supplemented with many informal conversations over the years with colleagues and representatives from government agencies, transport operators, and other interested parties into what has become a ‘discussion paper’. It then constructs four future MaaS market scenarios and identifies implications.

The paper finds that MaaS, if widely applied, potentially offers a paradigm shift from transport being fundamentally provider-led (i.e. effectively fixed capacity being provided to serve an assumed unchanging demand), to being a more user-led system whereby the level and type of transport supply are adjusted in response to the specific desires of individual travellers. As yet however, it remains a niche product, and it is far from certain as to how it will evolve and scale up in future, particularly from a financial perspective. Major challenges exist for policy makers relating to with issues such as safety, data security and privacy, equity and the threat of dominant monopolistic suppliers distorting the marketplace. In particular, the role of local authorities will need to be less directive and be more facilitative and supportive of the ‘new’ sector in being network builders, and new regulatory structures will need to be examined. Additionally, data and payment APIs need to be standardized, administrative subsidy and investment programmes need to be more targeted and transparent.

\textsuperscript{*} Corresponding author.
E-mail addresses: m.p.enoch@lboro.ac.uk (M. Enoch), Stephen.potter@open.ac.uk (S. Potter).

\url{https://doi.org/10.1016/j.tranpol.2023.02.007}

Received 19 September 2022; Received in revised form 14 January 2023; Accepted 5 February 2023
Available online 9 February 2023

0967-070X/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).
2. Defining mobility as a service

The increasing role of services in developed and emerging economies is a key feature of 21st century society. In a variety of sectors, consumers have shifted from gaining utility by owning products to using a service. The service may involve access to products, but the user does not own these. Such a service may simply be the leasing of a product to which a consumer has personal exclusive access (as in a personal car lease or mobile phone service package), but some involve a stronger sharing economy model, with transport examples including car clubs (i.e. car sharing schemes in the USA) and shared/city bike/e-scooter schemes. The distinction here is that, whereas car leasing provides the same exclusive access to a vehicle as ownership, car clubs and bike sharing schemes provide on-demand access for a specific journey. A further stage in service development is the delivery not of access to individual transport products or services, but where the function of mobility is provided (Cook et al., 2006). This function might be to travel between A and B, which is what mode-specific public transport provides. But for more complex trips, multi-modal services are offered (such as the combined metro/bus/train tickets and smart cards offered by most major city systems in the developed world). A further development that modern IT systems and business models make possible is a more adaptable and comprehensive multi-modal package incorporating both traditional public transport and emerging shared transport services, where a service provider draws upon a portfolio of transport services to deliver a customised trip for the user. Such a ‘one-stop’ fully integrated and customised transport service concept has come to be termed as Mobility as a Service (MaaS).

MaaS is one example of a particular type of Product Service System (PSS), and there is a considerable research literature about the definition, nature and consumer responses to PSS covering a range of situations where the use of an owned product is replaced by access through a service (Mont, 2002, Tukker, 2015).

The different types of PSS, as noted in the above examples, has led to the development of a three level PSS classification (Hockerts, 1999; Cook et al., 2006).

1. Product-orientated, where service is added to owned products;
2. Use-orientated, when customers access products owned by suppliers, such as in a car club or bike sharing scheme;
3. Result-orientated, when consumers acquire results, such as when mobility is supplied to customers.

As noted above, traditional public transport is essentially a results-oriented PSS with MaaS integrating several services via a single user interface. Although Alyavina et al. (2022) sees MaaS as a “complex, diverse and novel concept [that is] difficult to describe through a single definition”, the definitions that are used place MaaS clearly as a customised level 3 PSS. For example, the EU MaaS Alliance’s definition of MaaS is that “Mobility as a Service (MaaS) integrates various forms of transport and transport-related services into a single, comprehensive, and on-demand mobility service” (MaaS Alliance website, 2022). The UK Transport Systems Catapult (The Transport Systems Catapult, 2016) takes a more digital economy stance, defining MaaS as “a digital interface to source and manage the provision of a transport related service(s) which meets the mobility requirements of a customer” (ibid).

In these definitions, MaaS envisages users buying mobility services as packages based on their needs instead of buying a ticket to use generic means of transport (Kamargianni et al., 2016). That said, one issue has been a lack of clarity as to what exactly MaaS involves (Hensher et al., 2021; Kayikci and Kabadurmus, 2022; Hensher, 2022), with the term sometimes simply used as a marketing phrase for a novel isolated service.

As a level 3 form of PSS, MaaS is generally perceived as being a one-stop online ICT interface which aims to deliver a seamless travel experience. It comprises:

- an intermodal journey planner (providing combinations of different transport modes: car-sharing, car rental, metro, rail, bus, bike-sharing, taxi, etc.) that operates in real-time;
- a single payment portal, whereby users can pay-as-they-go or may buy a ‘service bundle’ in advance; and
- a booking system incorporating every stage of the entire end-to-end journey.

As well as charging the user for providing a journey, MaaS software algorithms would also allocate income to the various transport service providers. Such ‘back office’ systems already exist, having been developed for online services involving multiple orders for customers on a platform with multiple providers – Amazon and airbnb being prime examples. For transport, there are limited examples in less complex situations. One is that, in booking train journeys in the UK, a traveller can add a bus pass at each end of the trip; the booking software both adds a charge to the user for this additional service and forwards the revenue to the bus operator concerned. Acknowledging these aspects, a broader definition by Smith and Hensher (2020) suggests that MaaS could refer to “large-scale and global or small-scale and local; offer either pay-as-you-go and/or subscription plans (tailor made or not); integrate other functionalities and/or types of services as well; be delivered by any type of actor or actors; and be set up with or without an explicit purpose to produce benefits to society” (pp.56).

The business model for MaaS is of central concern but was initially somewhat overlooked in technically oriented approaches to its development, though this has changed more recently – e.g. see Van Den Heuvel et al. (2020), Esztergár-Kiss et al. (2020) and Vij and Dühr (2022). One particular challenge is that MaaS aims to integrate subsidized or low margin services delivered by multiple operators, whilst also delivering value to users, whilst a second is that it does not fit well within current institutional arrangements – a difficult starting point (Smith and Hensher, 2020). The paper adds that the uncertainty of the business model is a major cause of issues around integration, customer relationships and collaboration.

As a consequence of the above issues, there is some significant scepticism that MaaS will ever actually become a mainstream proposition, with the need for a MaaS champion and an overall Government-led proactive approach seen as critical to its success (Hensher et al., 2021; Hensher, 2022). This is supported in a review of 50 transport experts from around the world, only eight of which expected mobility brokers to be an important stakeholder in the provision of transport services in future (Enoch et al., 2020).

Two alternative service delivery options for incorporating MaaS into the transport system are considered in Wong et al. (2020): 1) an economically deregulated model, 2) a government contracted model. Interestingly this paper sees western Governments stepping away from the service provision role and being involved at arms-length. One interesting aspect of this involvement could be to regulate for network efficiency by pricing access to roads. Meanwhile, van den Berg et al. (2022) considers the potential of four different market structures on prices, demands and profits, namely.

1. The integrator model. Transport firms set their own prices for direct services and the MaaS provider sets the cross-network prices.
2. The platform model. Transport firms set all the prices and the MaaS provider only offers the platform.
3. The intermediary model. Transport firms are the leaders and set their prices first.
4. The regulated model, where transport firms are required to offer their services to the MaaS platform at marginal costs.

Overall, this paper finds that the integrator model performed best by contributing to lower prices due to increased competition and less serial marginalisation.

Fundamentally, MaaS could generate revenues to providers in the
following ways (The Transport Systems Catapult, 2016).

1. When a traveller buys a service bundle of transport journeys through the MaaS provider, the MaaS provider would take a fee before passing on those revenues to the transport operators who deliver the services.

2. MaaS providers can generate income through the data feeds that their Digital Service Platform generates, which transport operators and/or other software service providers could use to market and enhance their service offerings.

3. The platform could also host advertisements or attract commercial sponsors.

This is the sort of model used by digital service providers such as Amazon or the variety of holiday accommodation platforms. The second income stream could be significant were data also marketed for other purposes, such as consumer profiling. This is an important commercial aspect of many free internet services but raises personal privacy issues, particularly were MaaS to develop commercially. This would link to targeted advertisements or the whole MaaS service could have a commercial sponsor (as, for example, with the Santander bike sharing rental scheme in London).

3. The emergence of mobility as a service

MaaS has emerged from two main sources. The first is from the transport sector where there has been a long-standing desire of policy makers to deliver ‘total journey solutions’ by integrating public transport routes, e.g. Tabassum et al. (2017), timetables e.g. Ibarra-Rojas et al. (2015), information e.g. Tavares et al. (2015), and ticketing e.g. Puhe (2014). Related to this, there was impetus from the development of paratransit systems. These were mainly isolated transport services, but there are important insights from small-scale Dial-a-Ride (DaR) and Demand Responsive Transport (DRT) service trials in Scandinavia, Germany, the Netherlands, North America and the UK, e.g. Ambrosino et al. (2016) and new DRT services (e.g. Potter et al., 2022a). In addition, there have also been other level 2 PSS systems, such as car and bicycle sharing solutions. Over time these have begun to be blended within this picture, e.g. Shaheen et al. (2012).

A second source for the MaaS concept has come from the IT industry; here ‘Mobility’ is only one of dozens of ‘as-a-Service’ concepts (e.g. Software, Ontology, Routing, Monitoring) now being marketed (Sharma, 2016), and this revolution in data processing capability is having major impacts on the transport sector.

This joint heritage produces two main forms of MaaS-type schemes.

- Relatively local/regional-level, multi-modal and often local authority or public agency ‘transport or society-led’ solutions, such as Ubigo, SHIFT, EMMA, Mobility Mixx, HannoverMobil, Moovel, Chariot or Qixxit, (Kamargianni et al., 2016; Ambrosino et al., 2016).
- Internationally focused, larger-scale, uni-modal and private-sector ‘commercially-led’ solutions, such as Lyft, Uber (and formerly Bridj). These are level 2 PSS (i.e. isolated transport services) and not the level 3 MaaS concept, but the learning and market development achieved could lead to them providing a Level 3 MaaS offering.

As noted by Watanabe et al. (2017), the second involve the more significant actors and commercial MaaS offerings could be a lucrative development using IT firm’s existing core skills and platforms. So MaaS could emerge as something that, for example, Google Maps might provide as an additional service to its existing trip planning function. Adding MaaS to such a platform could generate additional income for an already successful business model.

4. The changing mobility system

Traditionally, mobility systems have comprised of fixed assets (infrastructure – i.e. rights of way, power and control equipment, storage and maintenance depots, plus passenger stations and stops) and mobile units (vehicles) which are combined together with a set of rules for their operation to enable the movement of goods and people (Vuchic, 2007). This system design means that:

- Users have little direct influence on the type/level of public transport service they receive, unless they access a lift, or pay significantly more for a taxi or minicab.
- Operators are legally required to provide the services for which they are registered, whether or not anybody actually uses them at particular times. Such regulations exist whether the operator is state owned or private.
- Services are initially introduced based on limited amounts of historic customer needs/preference data, which is aggregated and averaged across the day/week/year and the route network using ticketing data where available.

With MaaS, the first key change is that transport users and providers now instantaneously communicate their needs via Digital Service Platforms (DSPs) which, for a charge, makes the most appropriate journey match (Djavadian and Chow, 2017). The second key change concerns the emergence of a whole new suite of shared services, a development that has occurred independently of MaaS and which could complement (or compete with) traditional public transport services. These include lift sharing (ride sharing in US parlance), bike sharing, micro-transit, and car club schemes (Shaheen, 2016). These changes raise the possibility that:

- Users can now tell operators of a transport service exactly the attributes they want of it: time of arrival, origin and destination points, degree of flexibility, type/level of comfort required, and price they are prepared to pay;
- Providers, which are now more numerous and offer many more types of service than previously, can choose to respond, or not;
- Users, providers and regulators can readily monitor, evaluate and predict service availability and hence adjust their travel behaviour, market strategy, or policy decisions accordingly.

A MaaS system would include conventional route-based public transport systems, which crucially provide the high capacity and network efficiencies needed in high density urban situations. However, MaaS would combine this with new shared services to be able to offer a quality mobility product in situations where conventional public transport struggles or is unavailable, for example in lower density suburbs, cross-metropolitan fringe trips, smaller settlements and rural areas (Wong et al., 2020; Potter et al., 2022b).

In principle, this should result in customer-led services, tailored to the actual conditions in the market at any given time to the benefit of all, not least because suppliers can ‘dip in and out’ of the sector as they like (just like a someone might offer a spare bedroom through airbnb for a while and then withdraw it). This effectively represents a ‘paradigm shift’ from the traditional operator-led public transport environment described earlier. Effectively, new IT-led services, and MaaS in particular, actively manage both supply and demand in near-real-time and in parallel – something which has not previously been possible (Flenser, 2017).

Such a goal is one with which the IT industry is familiar and opens up a strong commercial perspective; consequently a significant amount of work is underway in the IT sector (Shaheen, 2016), albeit much of it likely to be confidential. Specific areas of operational focus include improvements to Digital Service Platforms, (Ruutu et al., 2017); the optimization of vehicle dispatch locations (Dimitriou et al. (2016); surge
pricing and labour supply (Zha et al., 2017), and research on exploring demand dynamics (Kourt et al., 2017). Payment and ticketing systems are another topic; for instance, the use of electronic fare coupons for public transport as a means of developing a revenue stream that is suitable for MaaS (Chow, 2014). Privacy and security of MaaS systems is another component that has been studied (Belletti and Bayen (2017), whilst the legal and institutional issues around MaaS have been explored by, for example, Flores and Rayle (2017), who present a case study of the regulatory approach around Uber and Lyft in San Francisco. Relatively little has been written concerning the implications of MaaS for the vehicle to infrastructure interface, though there is more about the technological workings of vehicular ad hoc networks (VANETs) which enable vehicles to communicate with each other (V2V), as well as with roadside infrastructure units (V2I) (Benslimane et al., 2011). One exception is where MaaS features in an article on slot booking systems (Lamotte et al., 2017).

Few references were found using the terms ‘Freight’ or ‘Logistics-as-a-Service’, and these were focused on the technology of the Digital Service Platforms involved (Nowicka, 2014; Niharika and Ritu, 2015). Instead, terms such as ‘Smart Logistics’, ‘Smart City Logistics’, ‘Smart Connected Logistics’ are used, and there is just one reference (Grazia Speranza, 2016) that provides some ideas as to how these concepts could evolve in the future.

Finally, there is research into potential MaaS markets. Thus, Zha et al. (2016) conducts an economic analysis of ride-sourcing markets and Harding et al. (2016) examines the impact of Uber-type solutions on the taxi market. Zijlstra et al. (2020) reports early adopters to be young, healthy, active and highly mobile, with a high socio-economic status, high levels of education and high personal incomes. Smith et al. (2018) draws on 19 interviews with MaaS actors in West Sweden to generate three scenarios – market-driven, public-controlled and public-private – to consider how MaaS could develop and affect conventional public transit in terms of the scope, usage, access, business model, competence structure and brand value. It finds that developing a regulatory framework to secure public benefits, whilst at the same time not stifling innovation, will be crucial if MaaS is to be mainstreamed. Etszergár-Kiss et al. (2020) finds three cluster groups, namely 1) Route planners, which involves a few modes of transport but provides an extensive service; 2) Third parties, which has primarily private MaaS operators; and 3) Public systems, which usually includes public MaaS operators. Such studies are comparatively rare and focused on quite specific contexts, hence the broader scope of this paper.

5. Future scenarios for mobility as a service

In framing how the market for MaaS may evolve in the future, this paper presents the results of a Scenario Planning exercise. Scenarios are ‘imagined future worlds’ which do not represent a future prediction but present a range of plausible futures to allow policies to be ‘tested’. This study undertook the following steps.

1) Identify drivers and define the axes;
2) Develop the scenarios;
3) Consider the implications.

Driver Analysis involves identifying key uncertainties in society and systematically assessing their implications. The method adopted was influenced by FHSC (2014) with the identified external drivers (i.e. technological, political, institutional, social and economic) influencing context-specific drivers relating to the type of user engagement with future mobility services. This identified the potential impacts to individuals, operations and society more generally. These aspects are now explored in turn.

5.1. External drivers

Technology is perhaps the most important driver concerned. Understanding the development of new products and services, Coombs (1996) concludes that technology-push ‘Schumpeterian’ processes are more likely to be important at the birth of an industrial sector but are progressively moderated by demand-pull ‘Schmookler’ processes with time. Specifically, digitalization, incorporating the Internet of Everything (IoE), sensors, mobile devices, consumer electronics, provides “the most significant technological trend faced globally” (Leviakanga, 2016), especially when combined with internationally integrated telecommunication infrastructure and advanced programming algorithm methodologies. Not only transport, but the reasons people travel (employment, leisure, shopping) will be affected in ways that are very difficult to predict. For MaaS, crowdsensing whereby contextual data is accessed from mobile sensing devices is one especially interesting developing technology (Heiskala et al., 2016). In addition, the shift towards increasingly autonomous vehicles (Alessandrini et al., 2015) represents a major change in how transport will be delivered in future. There is also the forecast growth of so-called ‘little vehicles’ or ‘micro-mobility’ i.e. mobility scooters, scooters, e-bikes, velomobiles, motorized skateboards, hoverboards, and other small, battery-powered low-speed vehicles, which could become significant short distance and feeder modes of travel.

Political drivers include the long-term trend in many countries for reductions in public spending for services such as public transport subsidies (Stiglitz, 2010). There have also been political moves to deregulate certain policy sectors (such as planning for example), and the ideal of promoting ‘choice’ as a means of improving service. But there are also growing concerns about climate change, energy security, congestion and poor air quality that have pushed governments towards ‘encouraging’ people to use cars less, by increasing fuel taxes or banning vehicles from city centres.

Institutional drivers are also promoting change within the intermediate transport mode supplier sector. One aspect is that the previously distinct leasing and rental sectors are becoming increasingly blurred, whilst multi-national transport corporations are investing in the new intermediate modes. For instance, in recent years rental car provider Avis Budget bought out car sharing operator Zipcar to expand its market reach, and car manufacturer BMW launched DriveNow, a point-to-point car club service, in partnership with car rental firm Sixt. Europcar acquired the eCar club and has integrating it into its commercial profile.

Social drivers include the rising proportion of elderly people no longer able to drive, and younger people increasingly excluded from car use through more demanding driving tests and rising insurance premiums, as well as increasing housing costs and attitudinal factors (Delbosc and Currie, 2013). Delbosc et al. (2019) notes that young ‘millennials’ drive less, tend to be city-oriented, use urban public transport and app-based cab services. But in some cities there are fewer alternatives to driving thus limiting the development of less car-intensive behaviours. There is also a new culture of ‘collaborative consumption’, whereby material possessions are lent and borrowed (Cheng, 2016), with attitudes to issues such as privacy also continuing to develop (Cruickshanks and Waterson, 2012).

5.2. Contextual drivers

In exploring how context may feed into future mobility trends, one study from the New Zealand Ministry of Transport’s PT2045 project devised four scenarios, of which two ‘Mobility Marketplace’ and ‘Competitive Commons’ involve MaaS elements (New Zealand Ministry of Transport, 2018). Mobility Marketplace assumes a low population density setting and that, whilst sharing will become common, the private car remains important. The Competitive Commons speculates that car ownership will be far less important in a high-density environment with far more sharing options being available. Interestingly both
scenarios sit in the ‘partially automated’ as opposed to the ‘fully automated’ future space, suggesting that MaaS may be superseded should driverless vehicles become universally adopted.

However, the development of new forms of autonomous transit systems could considerably widen the scope of a MaaS approach (Potter et al., 2020). This can constitute another future scenario (Enoch, 2015), with a convergence of modes towards a universal driverless taxi service. In bringing these findings together, Snellen and de Hollander (2017) suggests that demand for mobility services will become increasingly informed. There will be an increased choice of transport options, travel time will be more productive, the geography of destinations will change, and the mobility system will become more complex. Finally, the advent of self-driving vehicles will produce further significant changes. Taking a similarly broad view, Table 1 suggests how the design of the ‘public transport’ service may begin to evolve in the future as a result of the changing circumstances mentioned, and how the operational, regulatory and planning mindset may need to adjust.

5.3. Impacts

In devising the scenarios, it is helpful to first review a series of MaaS studies on how people interact with MaaS, how the systems work operationally, and at how MaaS systems may impact on society.

At the personal level, in one study of a small-scale MaaS operation, on Ubigo in Gothenburg, the key service attributes identified by users included the ‘transportation smorgasbord’ concept, simplicity, improved access and flexibility, convenience, and economy (Karlsson et al., 2016).

There is more research on the growth and development of Uber, e.g. (Watanabe et al., 2016; Harding et al., 2016), albeit this is a level 2 PSS system. In one study of a small-scale MaaS operation, the key service attributes identified by users included the ‘transportation smorgasbord’ concept, simplicity, improved access and flexibility, convenience, and economy (Karlsson et al., 2016).

At the personal level, in one study of a small-scale MaaS operation, on Ubigo in Gothenburg, the key service attributes identified by users included the ‘transportation smorgasbord’ concept, simplicity, improved access and flexibility, convenience, and economy (Karlsson et al., 2016).

Similarly, Rio (2016) examines the influence of Uber on ethnic groups in Baltimore, and Cheyne and Imran (2016) explores the effects of MaaS on energy use in small towns in New Zealand. Meanwhile Butler et al. (2021) notes that MaaS led to reduced vehicle kilometres travelled, less parking, and reduced private vehicle ownership; and improved social equity. However, they also note that MaaS struggles to appeal to older generations, public transport users, and, in particular, private vehicle users. Respondents to a Delphi study expect MaaS to operate first in urban areas and then to rural areas over the next decade; and early adopters to be younger people, current public transport users, and flexible travellers (Jittapriom et al., 2020).

At the operational level, the Ubigo system was found to blur modes (in terms of services, infrastructure, information, and payment), and this blurring between public and private operators proved challenging due to the regulations and institutional barriers (Karlsson et al., 2016) which is also emphasised in other studies (Potter et al., 2020, 2022a). Sulskyte (2021) notes that limited cooperation between stakeholders is a barrier, whilst more broadly Butler et al. (2021) reports supply side barriers relating to lack of public private cooperation, business and political

Table 1
Transiting from a traditional to a possible future public transport model.

<table>
<thead>
<tr>
<th>Nature of vehicles</th>
<th>Nature of infrastructure</th>
<th>Schedule-type</th>
<th>Route-type</th>
<th>Stop configuration</th>
<th>Information (delivery basis)</th>
<th>Pricing basis</th>
<th>Pricing structure</th>
<th>Pricing elements</th>
<th>Nature of service delivered</th>
<th>Operational philosophy</th>
<th>Operational mechanism</th>
<th>Dominant demand paradigm</th>
<th>Operator strategic direction</th>
<th>Operational strategy</th>
<th>Operator objectives</th>
<th>Operational strategy</th>
<th>Operating environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holistic, specialist, single use, manually driven.</td>
<td>High cost, specialist infrastructure (for transport, even single mode)</td>
<td>Fixed timetables</td>
<td>Fixed routes</td>
<td>Checkpoint to checkpoint (few to few)</td>
<td>Static information</td>
<td>Fixed pricing</td>
<td>Fixed pricing</td>
<td>One price per journey leg</td>
<td>Person journey level</td>
<td>Supply-led</td>
<td>Planned in advance</td>
<td>Maximise patronage</td>
<td>Achieve economies of scale</td>
<td>Cost minimisation</td>
<td>Aims to standardise service product</td>
<td>Small number of large transport operators</td>
<td>Modular, generalist, multi-functional, automated.</td>
</tr>
</tbody>
</table>
support, service coverage, and vision.

Taking a market perspective, success for MaaS Digital Service Platforms depends on “gaining a critical mass of end users, developers, and service providers and achieving self-sustaining growth and scalability” (Ruu et al., 2017). Arriving at the right business model is vital in terms of pricing structure and building up a critical mass of service developers and providers on the one hand and service end users on the other. Clearly the number of competitors is also important, as is the degree of interoperability between the platforms – a high level of API standardization is desirable. Thus, Bahamonde-Birke et al. (2021) highlights the likelihood of a MaaS monopoly occurring, particularly with the widespread adoption of autonomous vehicles. Ambitiously, Wong et al. (2020) proposes a government-contracted model for MaaS, where the package includes a form of road pricing that is sensitive to time of day, geography and modal efficiency to help improve the broader transport system and deliver more sustainable outcomes. Aligned with this view, is that the financial and sustainable success of MaaS is by no means guaranteed, and crucially depends on how operators and users engage with the concept (Alyavina et al., 2022).

At the societal level, simulations of autonomous shared taxis in Lisbon, indicate a 45% per kilometre reduction on current public transport fare levels and significant land savings (if properly ‘locked in’) (Martinez and Viegas, 2017). This simulation study notes that shared fleets will compete with (and even replace) taxi and bus services, which may be desirable, so public governance will need to adapt. Enabling the sharing of autonomous vehicles is also seen as an important means of limiting potentially negative externalities (e.g. vehicle numbers, congestion, sprawl) following rapid AV adoption (Gruel and Stanford, 2016). Less specifically, societal impacts could potentially be significant and will need to be carefully managed (The Transport Systems Catapult, 2016). One other perspective is that MaaS provides a real opportunity to match customer needs more closely to service supply and support conventional public transit services, but this is likely only if institutional frameworks can be modified (Hensher, 2017) – an issue also identified by Sulsky (2021). Guyader et al. (2021) also notes the importance of institutions in the MaaS ecosystem. Finally, Butler et al. (2019) concludes that consideration of local characteristics is critical for successful implementation, there being no ‘one-size fit all’.

6. Scenario development

From the above analysis, three MaaS dimensions were explored.

- Market consolidation ranges from fragmented to consolidated, from perfect competition, to monopolistic competition, oligopoly and finally monopoly.
- Service consolidation again ranges from fragmented to consolidated, from single components of MaaS such as payment services, booking services, brokerage platform, or specific types of journey, to operators that provide every element.
- Operational scale could range from the neighbourhood level to the global.

In mapping these, first we adopted all four possibilities from the market and service consolidation axes. Second, we applied what seemed like the most interesting operational scale to each of these, such that the influence of scale could be considered. From this framework, four scenarios emerge, namely.

1. Consolidated market and consolidated service (local/regional);
2. Consolidated market and fragmented service (global);
3. Fragmented market and consolidated service (national); and
4. Fragmented market and fragmented service (multi-scale).

The intention here was to create plausible scenarios which provided sufficient scope to explore contrasting futures around the purpose and intended goals of MaaS, the roles of stakeholders in delivering and regulating MaaS, and the strategic choices facing these stakeholders.

6.1. Scenario 1: Highly consolidated market, and highly consolidated services, (Local/regional scale)

This scenario represents the model seemingly most expected by many local and regional governments, particularly in Europe, whereby each public transport authority would establish its own MaaS platform monoply across its operating region. Qualifying transport service providers, potentially a mix of commercial, public-sector and/or community operators of both traditional public transport and shared transport services, would then join each platform and could apply for subsidy to provide non-commercial but socially necessary journeys. Current examples of such schemes are being piloted in Helsinki, Finland and the West Midlands in the UK.

Benefits: Strong local government control should ensure the market is operated in the public interest and be properly coordinated – fare levels, minimum service quality and high data management standards (including requirements to share all operational data with the public authority) being assured through regulatory controls. Social inclusion and equity concerns would be addressed through provisions in the service agreements detailing requirements of the areas/person groups to be served, and through price caps and/or user-side subsidy regimes. Services would also enjoy a very local flavour which might be appreciated by users.

Issues: Attracting providers to operate under such conditions may prove challenging due to high entry barriers. This could result in limited levels of competition in less attractive market environments. Diseconomies of scale and scope may also stifle innovation, reducing potential efficiency gains and limiting consumer opportunities.

6.2. Scenario 2: Highly consolidated market, and highly fragmented services (Global scale)

This global oligopolistic future sees multi-national commercial organizations each entering the MaaS marketplace to capture the business in their particular field of operation. Transport operators such as Stagecoach and Deutsche Bahn would seek to dominate the provision of traditional public transport; car rental companies like Avis and Hertz would manage most of the car sharing operations; Uber and Lyft would lead the provision of taxi-like lift sharing options; and big car park operators (such as NCP in the UK) would provide the car parking spaces. Crucially almost everyone would connect with each other through a fully open and accessible DSP (perhaps provided by a global IT provider such as Google) and pay through credit card payment systems.

Benefits: Significant efficiency savings due to scale economies, and a focus on market-leading expertise in each specific sector. The market would be stable and consistent across the world, so especially attractive to highly mobile consumers.

Issues: High barriers to entry would limit innovation and could
prevent improvements from being adopted. There may also be issues with conflicting common objectives across the contributing service provider elements, and a lack of integration in terms of intra-organisational information and payment flows. Regional public authorities may not have the leverage to ensure that the needs of disadvantaged citizens are met, nor to insist that operational data be shared with them. More broadly, it is also unclear how services would be effectively regulated, for example around the management of personal data and/or the sharing of operational data with the public authority and other entities.

**Implications:** Some elements of the service chain would be less competitive than others – e.g. payment systems and DSP platforms – which together with the fragmentation of the MaaS service in this scenario could mean there is no single MaaS regulation agency, with regulatory duties spread across various financial, competition, data, communications and transport regulatory agencies. Regulatory duties would need to be properly resourced if consumers were not to be disadvantaged and abused. National and regional governments would therefore need to be alert to this scenario occurring and be pro-active in developing measures to safeguard the public interest, ideally before such a MaaS ecosystem became established. This is especially important, given some MaaS components will likely take off incredibly quickly (as has happened with Uber, and contactless payment by bank cards on public transport).

### 6.3. Scenario 3: Highly fragmented market, and highly consolidated services (National scale)

A range of service providers (large and small) that individually offer different components form partnerships and/or merge with others. A hypothetical example might occur where an Amazon-Arriva-HSBC partnership would compete with MTR-Mastercard-Yahoo-Toyota, and Uber-Diners Club-SNCF to deliver seamless end-to-end journey solutions by the full range of modes to transport users in a monopolistic environment. Users making trips that are recognized as being ‘socially desirable’ are directly subsidized with there being no supply-side subsidies. All but the most rural areas would have at least two or three providers, and users would choose the package that suits them best. Perhaps the closest parallel to how such a market might look is the telecommunications market in nation states across the European Union. Here, on average there are 3–4 mobile network operators per member state which compete by offering a range of subscription and pay-as-you-go ‘packages’ comprising telephone, text, data, and other ancillary services to consumers who then choose the most offer that best meets their needs (EC, 2018; Hensher and Mulley, 2021).

**Benefits:** Low to medium barriers to entry would produce a diverse and contestable market which is steadily improved as new innovations are adopted, whilst consumers are still able to shop around for deals most appropriate for them. Objectives across the contributing service provider elements would be consistent, as would inter-organisational information and payment flows.

**Issues:** For consumers, it could be challenging to understand and secure the deal that is best for their needs whilst switching between providers can often be an arduous process (arguably as for mobile phone consumers currently). More generally, prices are likely to be set above marginal cost due to allocative inefficiencies with particular implications for the socially disadvantaged. Once again, there may be challenges for public authorities in accessing operational data from the MaaS providers, and in the event perhaps the majority of authorities will not deem it to be a worthwhile exercise. As for the previous scenario, the need for public authorities to be pro-active in terms of protecting the public interest is clear – retro-fitting requirements once such a system is operational would not be easy when facing such powerful and well-resourced operations.

**Implications:** Regulators may need to intervene to ensure clarity of customer information, that customers are not unfairly ‘locked in’ to deals that may not suit them, and that prices are not exploitative. It is also possible that nations will adopt a high level of regulatory alignment to encourage more service providers.

### 6.4. Scenario 4: Highly fragmented market, and highly fragmented services (Multi-scale, from neighbourhood to global)

This model envisages a highly fragmented, multi-scale marketplace, almost from the neighbourhood-level to the global level. This is highly competitive and comprises many thousands of transport service providers (ranging from individual ‘little vehicle’ owners renting out a scooter for a limited time period or car owners offering lifts for one-off trips, to local bus companies and multi-national multi-modal operators) promoting their service offerings to a multitude of MaaS DSPs. Users pay via their own favoured banking service thanks to the adoption of standardised data and payment API structures. Fare levels change in real-time (within bounds), according to the service attributes required by the user, the level of demand for the service, and the quality of service delivered. Such an environment is already beginning to evolve in London, whereby cashless contact credit/bank cards are set to replace the dedicated Oyster transport payment card and a whole range of new mobility products are now being trialled – e.g. Via, Uber Pool, Smart Ride and Chariot (bus-taxi hybrid schemes); Urbo, Mobike, Ofo (shared bike schemes); Drivy, DriveNow, Zipcar (car club schemes); GoCar-Share, BlaBlaCar, liftshare.com (lift sharing schemes).

**Benefits:** Barriers to entry are low, so users have a large degree of choice, whilst poor quality and/or overpriced services are quickly forced out of the market.

**Issues:** Low profit margins reduce the incentive for companies to innovate, so the growth of the sector may be limited. ‘Too much’ choice, especially in an unstable market where providers and services are rapidly changing, can also make it difficult for consumers to access the solution that would best meet their needs. Ensuring that public interest goals are met around data management, social inclusion, service performance and other indicators will likely be extremely challenging for local and national governmental entities in such a dynamic environment. Data sharing protocols within such an environment would be complex to establish, but especially necessary in this case given the ‘wild west’ nature of the operational environment.

**Implications:** Such a mobility eco-system could be chaotic without a firm regulatory framework in place from the start. This would need to be based on core operational and market principles yet be flexible enough to adapt to new service configurations and technologies and need to engender high levels of trust from all parties (governance, provider and consumer). Interestingly, under this scenario there may initially be scope for competing regulatory frameworks (potentially at the regional and/or national levels), which may in turn lead to best practice institutional regimes being created in the longer term.

### 7. Implications for decision makers

MaaS is still at an early stage in its development, as highlighted by the recent failures of two high-profile examples, both for financial reasons (Djavadian and Chow, 2017). Kutsuplus in Helsinki failed because massive scale was needed to make the economics work, but the significant public cost of doing that was too much for the local authority to accept. Similarly, Brijd in the USA ceased operating when it could not find a major investment partner to scale up its operations. More research is plainly needed on business models for the early stages of such innovations. A stepped scale business model is needed that is viable at all stages of innovation diffusion. The MK Connect example (Potter et al., 2022a) represents a stepped scale business model that works towards MaaS, in that this app-based service provides a platform for both DRT and route bus services. Once it becomes more established, the intention is to add in other transport services and evolve towards more of a MaaS product.
Key policy challenges will focus on the accessibility, availability, (cost) efficiency and acceptability of transport, whilst policy makers will need to switch from a reactive mode to being more proactive (Snellen and de Hollander, 2017). The American Public Transport Association (2016) proposes Public Transport Agencies become Mobility Agencies, and form partnerships and collaborations with (a wider range) of service providers. It adds that data and payment APIs need to be standardized, and that administrative subsidy and investment programmes be more targeted and transparent. Similarly, Miles and Potter (2014) suggests the role of local authorities will need to be less directive. Rather than being project managers, funders, and service providers, their role would become more facilitative and supportive of the ‘new’ sector in being network builders and leveraging access to finance and other resources as a partner agency. In this respect there could be lessons to be learnt from the travel plan sector, whereby the most successful examples benefit from partnership working between non-traditional transport actors, transport operators, and local authorities (Enoch, 2012). Similar conclusions were drawn by Calvert et al. (2019). In their study of the business models applied in on-demand shared-ride road transport niches, they noted that a key innovation was the emergence of new models of partnership working.

Results from a study exploring the uncertainties in implementing automated vehicle taxis focused on the need for an adaptive or flexible approach to policy making, to limit the potential for errors (Walker and Marchau, 2017). One approach could be to regulate the day-to-day aspects of each transport operator (driver licensing, subsidy allocation, etc.) almost as now, but to also classify operators by their level of specialist (e.g. occasional, regular, specialist), whereby the more specialist the operator, the tighter the regulations but the greater the operational benefits and opportunities (Enoch and Potter, 2016). ‘New’ modes would no longer be forced into operating pre-conceived service patterns and should allow for occasional providers to ‘safely’ join the transport market when an opportunity arises.

Taken together, these insights suggest a great deal of uncertainty still pervades the future of MaaS, which might indicate a ‘wait-and-see’ approach to policy makers. Yet there is a strong feeling that a significant re-alignment process is already underway, and this requires serious consideration and positive action by policy makers if they are to effectivly influence how this new transport paradigm ultimately develops. The best approach might seem to be as open and flexible as possible to the opportunities that arise, whilst being careful not to become locked into particular paths too early. Rather than seeking a comprehensive MaaS service, it looks like stepped approaches that leave options open may well be the best way forward. These might integrate on a platform only a few transport services but can then form the foundation for further development. On balance, it is likely that the transport policy landscape will look quite different in the years to come as MaaS-type services becomes more mainstreamed, a situation potentially messier and more difficult to manage than many transport practitioners and policy makers currently imagine.

Looking more broadly at the evolving transport market, traditionally transport planning and operation functions have focussed on work journeys, but in all developed economies, commuting is declining in importance as a trip purpose. For example in Britain even before the Covid-19 pandemic, commuting had already dropped to under 20% of the distance travelled, a trend accelerated by the development of new working practices (home and flexi-working) during the pandemic. Moreover, non-commuter trips (i.e. the school run and other trips to take another person somewhere) had increased by 20%, entertainment by 15% and holiday/day trips by 7% (Department for Transport, 2019).

Overall, as noted by Potter et al. (2022b), travel has shifted to involve more complex movements, to be less local (and hence walk trips have substantially dropped) and to be more geographically dispersed. In contrast to the predictable commutes of the 20th century, transport in the 21st century is increasingly shifting to dispersed patterns of behaviour that conventional public transport service struggle to serve. Instead, as noted in the report All Change? (Marsden et al., 2018), the major areas of travel growth are in social and leisure-related purposes. Geographically, the greatest increase has not been along major corridors to city centres but in suburban, urban fringe (‘peri-urban’) and rural areas (Hall, 2013). A long-term structural problem for public transport is that the core design of the traditional public transport regime itself (fixed route, high-capacity corridor services) is ill suited to the 21st-century landscape of travel demand. That is why it is important for MaaS to embrace new mobility services, while accepting that conventional public transport will continue to serve more traditional, higher density, travel purposes and routes.

8. Conclusions and future research

Overall, this paper finds that whilst interest in MaaS amongst researchers has rapidly increased in recent years, it does not yet have a major presence. MaaS potentially offers a paradigm shift from transport being fundamentally provider-led (i.e. effectively fixed capacity being provided to serve an assumed and unchanging demand), to being a more user-led system whereby the level and type of transport supply are adjusted in response to the specific desires of individual travellers. Accordingly, major challenges exist for policy makers, who will need to balance the promised benefits offered with issues such as safety, data security and privacy, equity and the threat of dominant monopolistic suppliers distorting the marketplace.

Whatever the eventual structure of the market, it seems unlikely that MaaS could provide major transport benefits to either users or policy-makers until it is applied at a large scale. A major challenge is in developing a business model that can work at a small scale and yet be effectively scaled up as demand increases. There is also an issue of the variable quality in transport services that MaaS draws upon to offer a mobility service. MaaS offers value where a portfolio of transport services need to be integrated to provide mobility to a user. Yet most existing public transport trips do not require this, and so MaaS will add little value to existing public transport users. Where MaaS would come into its own is if it were combined with serious improvements to transport services through the development of a range of new transit modes. DRT particularly comes to mind in this respect.

The Covid-19 situation, although happening after this research was conducted, is of relevance. In the wake of the pandemic, much has been said about making space for bicycles, developing public bike renting schemes and in legalising rented eScooters in the UK. A window of opportunity has opened where new transit modes, plus traditional ones such as cycling, could emerge from new patterns of travel. A transformative change could be facilitated by integrating these through a MaaS platform, together with other more flexible modes (e.g. Uber share and Via) and quickly delivered innovative high-quality public transport services (e.g. tram quality buses and autonomous vehicles). MaaS needs not just to integrate existing transport services, but to facilitate the development of new ones. In and of itself, a smart 21st century interface to deliver a 20th century set of transport services will do nothing but disappoint and fail to gain any users who have the option to use a car.

However, this still leaves the question of who should take the lead in the transition to such a future. Major transport consultancies see MaaS as the next big area for them. Local and regional transport authorities see MaaS as the solution to public transit failing to attract car users necessarily to MaaS as the solution to public transit failing to attract car users necessarily to MaaS as the solution to public transit failing to attract car users necessarily to MaaS as the solution to public transit failing to attract car users necessarily to MaaS as the solution to public transit failing to attract car users necessarily to MaaS as the solution to public transit failing to attract car users necessarily. But for both, the expertise, experience and the commercial returns seem likely to be outside of their fields. Instead, it is the IT services sector that is the most likely to develop viable MaaS-style offerings because MaaS is a logical extension of their existing operations, core expertise and business model. Consequently, transport practitioners and policy makers need to build alliances with this sector, not make futile attempts to duplicate and outcompete it. There is no chance of doing that.
Credit author statement

Marcus Enoch: Conceptualisation, Methodology, Formal analysis, Investigation, Writing – Original draft preparation, Writing - Review and Editing; Stephen Potter: Conceptualisation, Methodology, Formal analysis, Investigation, Writing – Original draft preparation, Writing - Review and Editing.

Data availability

No data was used for the research described in the article.

Acknowledgements

The initial basis of this work was a brief state of the art review (see Enoch, 2018) which was undertaken as part of the evidence base used for the Foresight Future of Mobility report (Government Office for Science, 2019). We gratefully acknowledge the support of the GOFS team and also the comments provided by our peers over the past five years or so on the topic of Mobility as a Service. Early results were presented to the 2020 Annual Meeting of the US Transportation Research Board (though not subsequently published) and feedback from that event and a subsequent conference presentation at CASPT in Tel Aviv is also incorporated into this paper.

References

Hensher, D.A., Mulley, C., 2021. Mobility bundling and cultural tribalism - might passenger mobility plans through Maas remain niche or are they truly scalable? Transport Pol. 100, 172–175. Hensher, D.A. and Mulley, C.
Kuennering, M., et al., 2013. Towards Seamless Mobility: Individual Mobility Profiles to Ease the Use of Shared Vehicles, IFAC Proceedings Volumes (IFAC-PapersOnline). IFAC.


