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Mobility as a service (MaaS): Charting a future context[☆]

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ABSTRACT

This overview article proposes a revised approach to improve the urban realm, against the backdrop of new models for delivering transport services as digitalisation, collaborative consumption and autonomous technologies take hold. We propose the concept of *modal efficiency* illustrated through a conceptual framework situating both existing and emerging modes of transport around spatial and temporal dimensions. This framework helps us evaluate how the push towards smaller and more flexible transport services in questionable settings can have significant and adverse effects on road capacity, increasing congestion and in the longer term impacting urban form. We propose linking urban land use characteristics to travel price and modal efficiency to improve the broader transport system and guide the sustainable development of our cities. Mobility as a service (MaaS) based on shared mobility and modal integration constitutes a major opportunity to deliver on these ideals, if organised appropriately. Widely diverging service delivery models for MaaS are introduced, including commercially-motivated models (which may exacerbate efficiency issues), and systems which incorporate an institutional overlay. We propose consideration of a government-contracted model for MaaS, where road pricing is incorporated as an input into package price, defined by time of day, geography and modal efficiency. In amidst the hype of new mobility technologies and services, a critical assessment of the realm of possibilities can better inform government policy and ensure that digital disruption occurs to our advantage.

1. Introduction

New mobility services and technologies while offering greater choice in mobility offerings have the potential also to generate unintended consequences that can compromise the ideals of sustainable cities. Shared mobility options facilitated by transportation network companies[1] (TNCs) and advancements in connected and automated vehicles offer immense opportunities and benefits but also stark realities in terms of risks to road capacity, traffic congestion, land use and the urban form, especially in the absence of strong regulation and control. The possible proliferation of point-to-point transportation, any continuation of universal vehicle ownership, unfettered deployment of autonomous vehicles, and the potential demise of fixed route public transport might wreak havoc on our cities and communities. Rarely are these risks recognised amidst the hype and dogma as technology players, TNCs, vehicle manufacturers, consultancies and think tanks promote new technologies and services as the panacea for present day mobility

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[1] Also known as mobility service providers, describing new ridesharing, carsharing and bikesharing operators who utilise a digital interface to match passengers with available drivers and vehicles.

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challenges. Too often, any impacts are considered in isolation without regard for feedback effects which could bring unintended consequences for the whole system. It is important, therefore, to bring greater clarity for what this future transport paradigm might bring and re-evaluate whether it aligns with the strategic objectives of government and vision for our cities.

A major driver of this new paradigm are so-called shared **mobility services** (Shaheen and Chan, 2016) coming online courtesy of TNCs who have developed digital platforms as a means of connecting demanders and suppliers. Demographic change is a major push factor for its uptake, encompassing youth licensing decline (Delbosc and Currie, 2013), drops in driving amongst millennials (McDonald, 2015), and attitudinal changes in cars no longer being held as a status symbol. Carsharing under various ownership (peer-to-peer/fleet managed) and operating models (return-to-base/one-way/roaming) are becoming a viable alternative to car ownership, not only in the urban core but increasingly also in more marginal suburban locations (Shaheen and Cohen, 2013). Recent research has also found that carshare members generally increased their overall use of public transport and active modes upon joining (Martin and Shaheen, 2011). Ridehailing or ridesourcing, a peer-to-peer service, has infamously disrupted the taxi incumbents, exemplified by the global behemoth Uber as well as SoftBank as the primary investor behind most ventures around the world. Early evidence suggests that ridehailing both competes with and complements public transport, though this depends on the exact market and demographic (Rayle et al., 2016, Alemi et al., 2018). Some studies have also pointed to increased congestion in cities as vehicles circulate in search of trips (Alexander and González, 2015, Hensher 2018b).

A new wave of ridesharing (casual carpooling) has also been developing (Chan and Shaheen, 2012), enhanced by ever more sophisticated ride matching capabilities (Teubner and Flath, 2015, Amey et al., 2011). As distinct from ridehailing[2], both the driver and passenger(s) share the same (or similar) destination, thereby reducing the number of cars and hence net road space required. The pooling[3] of trips previously occurring in single occupancy vehicles is also the rationale for the growth of microtransit, in either peer-to-peer form (as shared ridehailing), or government-contracted on demand bus services. The desirability of point-to-point pick-ups is quantified in Frei et al. (2017) and often evaluated against the trade-off of additional travel time on a pooled service to price these offerings—an interest for incumbent bus operators who are increasingly collaborating with TNCs and platform providers in an effort to ‘uberise’ their services (Boone et al., 2018; Wong, 2018).

New mobility services (in their modern incarnation) are made possible by advanced **mobility technologies**, front and centre being the near universal penetration of smartphones which many hail as the single greatest innovation for transportation in the last decade. Big data analytics, the internet of things, and autonomous vehicles, are all closely intertwined with a future in which proponents argue will offer more efficient vehicle use, optimising[4] transport networks, better utilising infrastructure and delivering a more seamless customer experience. Connected and automated vehicle technologies form the crux of these drivers, transforming societal relationships with cars, with implications for public transport provision by breaking the link between labour cost and service quantity. An expanding literature has been developing primarily through use of the stated choice methodology (Kyriakidis et al., 2015, Payre et al., 2014, Daziano et al., 2017) to understand acceptability and the public’s willingness-to-pay for driverless cars. Research is also continuing on the user acceptability of automated public transport, like heavy rail (Fraszczyk and Mulley, 2017) and autonomous buses (Piao et al., 2016), including how users’ knowledge of whether their service is driverless influences their preferences and support for automation.

New transport services and technologies including autonomous vehicles have been closely linked to the *as a service* concept, describing a new paradigm where mobility is no longer consumed as an asset (i.e., based on private vehicle ownership), but rather accessed on demand. The **mobility as a service (MaaS)** proposition is often described as a one-stop, travel management platform digitally unifying trip creation, purchase and delivery. Definitional work has been extensive (Jittrapirom et al., 2017, Kamargianni et al., 2016), including identifying the key elements of MaaS and evaluating tiers of integration. Other research (Sochor et al., 2016) has explored various trials presently underway across Western and Northern Europe (Ubigo and Whim being prominent examples), as well as case studies of the governance models and institutional contexts in these countries (Audouin and Finger, 2018; Smith et al., 2018). More recently, there have been empirical work on end user demand (Matyas and Kamargianni, 2017, Ho et al., 2018) and interest in the supply-side—envisioning impacts on public transport contracts (Hensher, 2017), the business ecosystem for service delivery (Kamargianni and Matyas, 2017), barriers with respect to firm collaboration (Smith et al., 2018a) and quantifying the idea of a mobility broker/aggregator (Wong et al., 2018). Academic work is joined by extensive grey literature in the form of industry/consultancy white papers (Juniper, 2018, TravelSpirit, 2017, KPMG, 2017, Cubic, 2016, Atkins, 2016), which are often filled with assertions, including the forecasted travel time savings under MaaS, impacts on congestion and environmental externalities. The supposed total value of the MaaS market is also a strong feature.

In reviewing the literature, we find there remains a divergence in exactly what constitutes MaaS.[5] Many of the supposed benefits are often presented unchallenged (and indeed with strong emotional ideology) and there remains a lack of understanding on the entire premise for MaaS, how it links with societal objectives, and what sorts of policies and regulations are required to guide its

[2] Some ridehailing TNCs are venturing into this space with new features like Uber Destinations which matches trips towards a driver/partner-specified locality, further clouding the distinction between ridehailing and ridesharing. We note TNCs tend to favour the latter terminology to distinguish themselves from taxi operators and help promote their social credentials.

[3] In this paper, pooling refers to the simultaneous use of a vehicle trip by different travelling parties (thereby increasing spatial efficiency), whilst sharing describes the successive use of a single vehicle for multiple trips/parties (improving temporal utilisation).

[4] Arguably as a partial optimisation only due to potential adverse effects on other markets.

[5] In the US, individual mobility services like carsharing and ridehailing have been described as MaaS. We view these as constituent components of MaaS, which describes a multimodal product integrated across the journey making decision chain. We argue the potential for MaaS to be greater than the sum of its parts.

development. Often, this void is filled by speculation. Some recent work is challenging the previously myopic mindset—including investigation of user objectives (Lyons et al., 2018), social welfare (Becker et al., 2018), congestion (Hensher, 2018b) and policy-making (Jittrapirom et al., 2018b). Matyas and Kamargianni (2018) presents the idea of MaaS as a mobility management tool, but the concept is far from advanced. We argue that some of these shortcomings may be linked to a definitional gap in terms of what MaaS is and what it aims to achieve. Whilst many see it as a technology or product, we see MaaS as the ultimate vision for our cities. Premised on shared mobility, modal integration and an institutional overlay, MaaS constitutes an opportunity to tame and manage some of the unintended consequences of individual mobility services and technologies—including the potential displacement of public transport and the unfettered influx of driverless cars. Under appropriate regulatory and pricing mechanisms, MaaS is an enabler of network efficiency. There are parallels in terms of what is achievable with reforms in other utility markets like electricity and telecommunications.

The purpose of this overview paper is: (i) to problematise an alleged transformation in the personal transport system; (ii) to introduce an analytical framework based on modal efficiency and prove its usefulness; (iii) to propose the potential role of MaaS in this new paradigm; and (iv) to suggest the best model for MaaS, with reference to different available alternatives. In Section 2, we investigate different scenarios for modal development and their implications for the urban realm. Section 3 situates the plethora of existing and emerging modes within the modal efficiency framework and considers how it relates to MaaS. Section 4 proposes how MaaS ought to operate to circumvent the described issues. Section 5 presents relevant actors in the MaaS ecosystem, considering different ways to organise service delivery and the merits of each. Finally, Section 6 concludes with our vision for government-contracted MaaS and a brief look at future research directions.

2. Emerging scenarios and implications

Cities, in bringing people and activities together, emerged as a solution to the transportation problem—reaping economies of scale from the shared use of infrastructure and services. Their success is built around sufficient population and employment densities, land use diversity and transit-conducive urban design—the oft-cited *three Ds* proposed in the classic paper of Cervero and Kockelman (1997). Urban policy contravening these principles eventually descends into a destructive cycle, characterised by congestion and sprawl which ultimately dilutes the benefits of any agglomeration (Graham, 2007). Given this, we believe encouraging a compact urban form to be a key overriding criteria with which to evaluate the efficacy of future transport developments. Further, we see the push towards individualisation and greater choice as a consequence of new digital capabilities creating significant challenges to how we manage the future of cities and other locations as having *place* utility rather than just mobility utility.

Having introduced individually the key mobility service and technology drivers of an emerging transport paradigm, we now consider these factors in totality and discuss two possibilities for modal development which we believe to be inherently problematic by contravening the ideals of sustainable cities. Two possibilities are proposed: (i) modal displacement, where fixed route public transport is replaced by new shared mobility modes facilitated by TNCs; and (ii) modal convergence, where all modes of transport eventually converge to an autonomous taxi-like service. We are not suggesting either will eventuate (though some do warn of it), but rather believe both constitute realistic scenarios (albeit extreme) which might occur given the current trajectory and in the absence of effective strong policies and regulation.

2.1. Modal displacement

The essence of fixed route public transport (or more specifically, mass transit) is to bring passengers of multiple origins and destinations onto a single vehicle, thereby becoming efficient in the use of road space. This constitutes an important spatial efficiency argument for public transport in encouraging the development of compact cities. New mobility services like ridehailing and microtransit serve as competitors to conventional public transport. Indeed, many TNCs had initially as their stated objective to replace public transport, through price and quality competition—described by some as offering “taxi-like services at bus prices”. This language has dialled down considerably as TNCs now seek to work with city authorities and complement public transport—in some cases even through direct collaboration or being a contracted partner (Boone et al., 2018). Whilst this is encouraging, public transport remains vulnerable—in particular, buses operating in mixed traffic conditions where they have not enjoyed the investment linked to constructing dedicated right-of-way. There exists external threats in the form of competition from TNCs but also internal drivers including pressure from within (and from government agencies) to ‘uberise’ their routes and services.

One of the ways TNCs have been able to undercut on price is that TNCs do not own their fleet and do not treat their driver/partners as employees (which adds related on-costs like benefits and taxes). Utilising independent contractors brings ethical dilemmas (Rogers, 2015), but has allowed TNCs to disrupt the taxi industry and threaten public transport viability. TNCs may pick the cream and undercut heavily profitable bus routes, leading to a downward spiral in service as bus operators who are obligated to meet community service obligations can no longer internally cross-subsidise to support marginal routes and services. There are parallels with (for instance) the minibus taxi industry in South Africa (McCaul, 1990) where with a similar model (albeit without the digital interface) operators were able to force out conventional fixed route buses under a lapse in regulation, enforcement and with incredible violence. As the destructive cycle begins, governments will have less impetus to subsidise increasingly costly conventional public transport—further accelerating its decline.

Perhaps in light of competition from TNCs, and having witnessed the damage they were able to inflict on the taxi sector, there is a fervent push amongst bus operators and government authorities to ‘uberise’ their offering by means of running on demand microtransit (see workshop Mulley and Kronsell (2018)). Of course, there have been previous incarnations of this movement as far back as the 1960s in the form of flexible transport services (including dial-a-ride) which have been driven by the impetus to reduce the overall cost of public transport provision, especially during evening and weekend periods when many services run empty even if the individual services have higher unit costs. These initiatives have generally been met by considerable challenges and often discontinued after a period of trial (Mulley and Nelson, 2009, Walker, 2012). Cost savings have been marginal and in many cases negative—not stemming from labour (generally at the same rate unless outsourced), vehicle kilometres (often may be more due to the personalised service), or smaller vehicle sizes (given the additional fleet required). There are often operational inefficiencies including more dead running and extra personnel required to manage these service offerings. The difference now is the addition of a digital platform, the success of which remains to be seen, and in the future automated vehicles which will render the labour cost issue insignificant. Studies like Becker et al. (2020) are quantifying exactly what sort of cost savings might be realised in an autonomous new world (and how this varies across developed and developing countries).

Whilst we recognise that on demand has merit in particular circumstances (both spatial and temporal), we warn against a wholesale replacement of fixed routes, stops and schedules. There are different philosophies on how to manage poor performing bus routes earmarked for on demand. One view is that dismantling them in favour of on demand is an admission of failure and will cause a downward spiral towards lower density and greater sprawl. An alternative would be to support these services with land use policies which increase density and land use diversity, in an effort to stimulate the agglomeration economies of cities (although we recognise this is unlikely a regional solution). More personalised services also lead to the issue of replacing the current access/egress component in terms of the walk to public transport stops and stations with motorised transport, with impacts on health and social inclusion. Geometrically, the result of smaller vehicles is significantly greater vehicle kilometres travelled (although this is fine if it results in reduced car use), with implications on emissions and congestion. Finally, we believe there to be also an intrinsic value to a public transport service regardless of its level success (often reflected by the community angst when routes are withdrawn, and also as a selling point for property), in terms of the accessibility potential that it symbolises. On demand service offerings do not convey the same image of permanence because of the absence of traversing a fixed route where they can be seen.

2.2. Modal convergence

Autonomous technologies have been said to improve travel flow and throughput (Talebpour and Mahmassani, 2016), premised on reducing headway (distance between vehicles), narrowing lane widths, optimising lane merges and the development of autonomous intersection management to facilitate the most efficient junction movements without the use of traffic signals (VanMiddlesworth et al., 2008). A major opportunity exists too, linked to potential savings in future infrastructure investments required. What remains unclear, however, is the net impacts on congestion as the urban form morphs to reflect this increased accessibility (Hensher, 2018b). Induced demand will also arise from (i) existing drivers as the time freed en route may encourage them to travel further (related to location choice over the medium and longer term[6]) and more often; (ii) from non-drivers (Harper et al., 2016), either by choice or circumstance despite it being positive for social justice and transport equality; and (iii) from the influx of zero-occupancy vehicles dead running to avoid parking or to reposition for their next trip.

Harb et al. (2018) conducted a naturalistic experiment to study the induced demand impacts of autonomous vehicles on people. Overall, participants logged 76 percent more kilometres, took longer trips and travelled more in the evenings than previously. In particular, retirees more than tripled their evening travel and nearly doubled the number of longer trips made (reflecting high latent demand). Three quarters of supposedly car-shunning millennials travelled more kilometres whilst 20 percent of all trips carried no passengers. Families with children were especially likely to send a car to pick up friends and family as they sat in their offices. These results are particularly worrying and the extra demand unlikely to be met by the promised capacity increase of autonomous technologies.

Automated taxis (also described as robo-taxis or taxibots) have garnered great interest in both the academic and popular literature and viewed as a panacea for their potential to deliver point-to-point services at low cost. The exact cost and service differential relative to public transport and private cars will likely determine their uptake and market share. Some authors, however, see an automated taxi service becoming the sole mode of transport available in the long term. Enoch (2015), as a prominent example, envisages a model where buses (due to the desire for point-to-point service), cars (due to externalities) and conventional taxis (due to a desire for lower cost) converge to become a universal automated taxi system (Fig. 1). Whilst Enoch (2015) recognises the issue with urban sprawl and increased vehicle kilometres travelled, he ignores road space as a scarce commodity in dense urban environments. Point-to-point transportation is by definition low volume and associated with sole or low occupancy vehicles which take up more road space per passenger transported (being less spatially efficient).

The Enoch (2015) modal convergence hypothesis is premised on a taxi model (operated by a mobility provider) which as a shared fleet is far more temporally efficient than one in which vehicles remain individually owned. More intriguing is the concept of an own and share model, as suggested by Musk (2016), where autonomous vehicles are privately held but hired out when not in use for driverless ridehailing. Temporal efficiency in this case will depend on the proportion of the population owning vehicles, which by extension determines the demand for ridehailing and the relative amount of time these vehicles will spend dead running. Spatial and temporal peaking issues also come to mind as with the case of one-way/roaming carsharing and dockless bikesharing.

The system design, operation and congestion impacts of an automated taxi regime has been the subject of some very advanced

[6] With links to Marchetti's Constant—the idea that we have maintained on average a one-hour per day travel time budget (30 minutes one way) throughout humankind, allowing cities to expand in size as transport technologies developed (i.e., increases in speed).

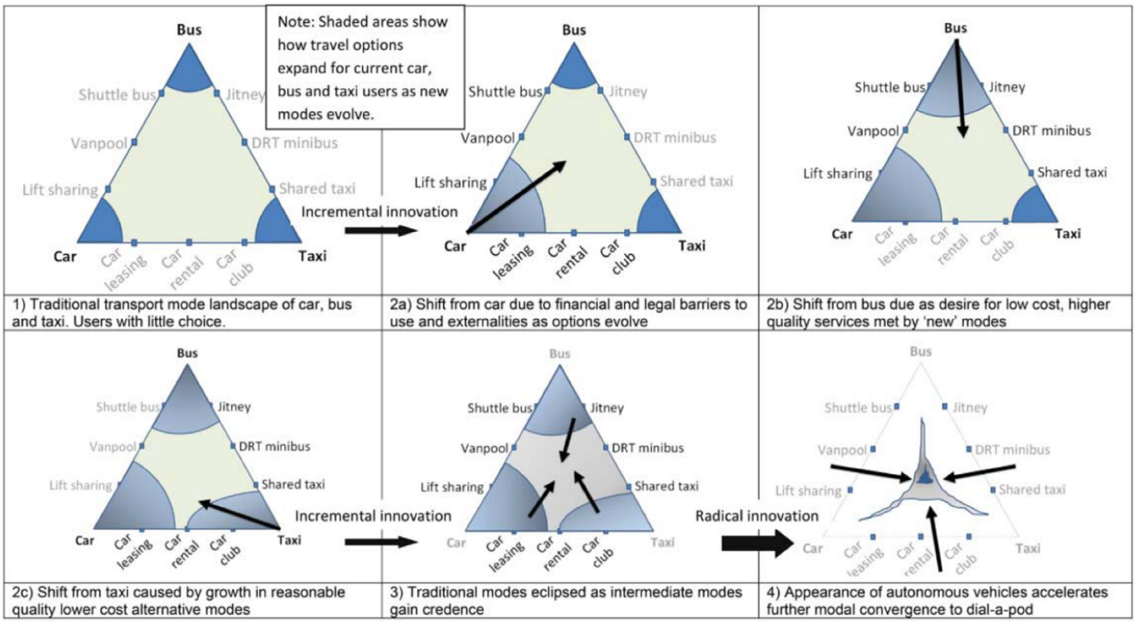

Fig. 1. The convergence of urban passenger modes towards an automated taxi service (Enoch, 2015: 918).

modelling. A simulation study (Martinez and Crist, 2015) conducted by the International Transport Forum in Lisbon, Portugal found that under a sole passenger driverless taxi scenario with 92 percent mode share (the other 8 percent on active modes with 0 percent using public transport), only a quarter of the existing car fleet will be required—though these will be used far more efficiently across time, doubling current vehicle kilometres travelled. This model also suggested that there would be only a minor increase in average travel times, based on the proposition that presently less than 40 percent of Lisbon's roads were used in peak periods. Further investigation revealed that distributors will see traffic increase by 76 percent and local roads by 115 percent, disregarding the road hierarchy and turning over communities where pedestrians ought to have priority to motorised modes, bringing associated noise, air and urban amenity externalities. These communal issues are too often neglected by traffic engineers and technology visionaries.

To circumvent the problematic outcomes of modal displacement and/or modal convergence, specific multimodal products must be developed. The essential prerequisite for this is a comprehensive digital interconnectedness of all involved actors, including individual modal operators and their regulator(s). A framework for how this integration ought to occur is now proposed.

3. Modal efficiency and MaaS development

The efficacy of various transport modes can be considered with reference to their spatial and temporal efficiencies—their ability to reap economies of scale by delivering maximum transportation across space (carrying multiple people per unit area) and time (providing mobility rather than staying idle). Indeed, all transport modes at their core may be considered as a function of space and time.[7] To consider the implications of the emerging transport developments for urban efficiency[8], it is necessary to develop an ordinal measure for modal efficiency in terms of spatial and temporal efficiency dimensions. In this spirit, the modal efficiency framework (Fig. 2) situates public, private, active and shared modes in each quadrant within a space-time plane defined by axes representing spatial and temporal efficiencies. Spatial efficiency is defined as passengers per vehicle/train consist (or per unit road space equivalent) whilst temporal efficiency can be considered as the proportion of time a vehicle spends on the road (in revenue service for public transport). Axes scales are estimated and intended to be illustrative only. Whilst there are links to attempts at quantifying the land consumption or time-area impacts of various modes (Shin et al., 2009, Bruun, 1992), the present framework is conceptual only and intended to form the basis for argument instead.

There are four quadrants to the framework which covers each combination of spatial and temporal efficiency. The **public modes** quadrant covers both bus and rail mass transit, which carry large numbers of people whilst providing service around the clock.[9] Metro/heavy rail carries the most people (even at crush loads) and rail rolling stock are used most extensively (some lines even running 24 h per day), due to them being the main corridors and the significant infrastructure outlay already invested. Different classes of buses then follow—rapid (light rail joins in this category), coverage and peak express—where efficiency depends on vehicle

[7] See think piece on modal etymology and nomenclature: https://sydney.edu.au/business/news-and-events/news/2018/03/05/bus-or-train-notes-on-naming.html.

[8] We focus on an urban context, but the same framework applies in a rural/regional setting, albeit at a different scale.

[9] The extent of temporal efficiency across the fleet may be measured by metrics such as the operational peak-to-base ratio.

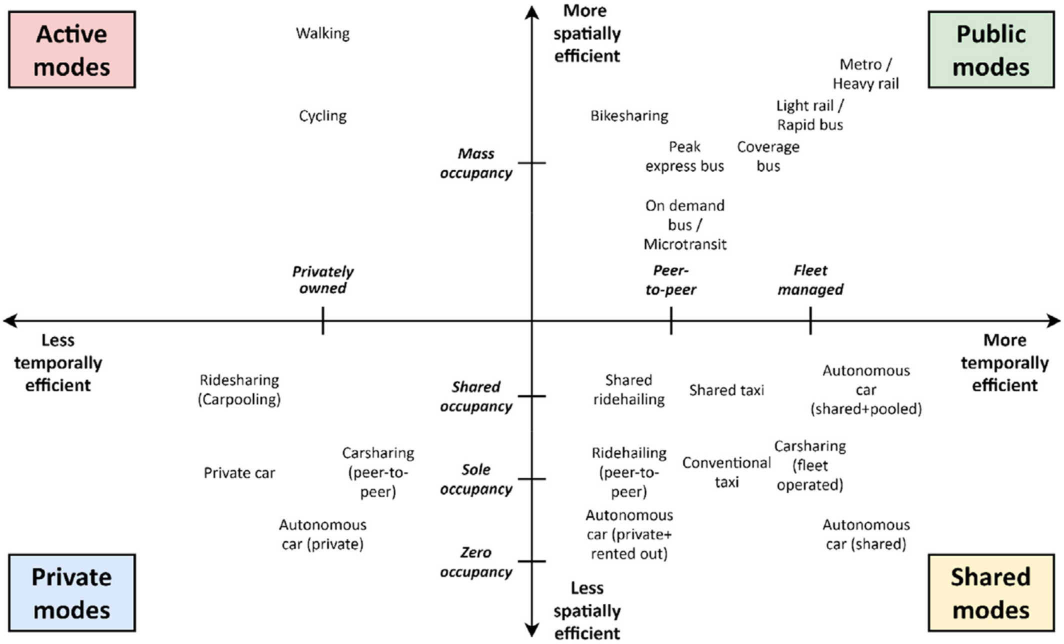

Fig. 2. The modal efficiency framework situates public, private, active and shared modes with respect to their spatial and temporal efficiencies. Both modal displacement and modal convergence scenarios developed see the centre of mass reside in the bottom right, shared modes quadrant.

size and the span of service hours. On demand buses and microtransit use smaller vehicles and in many cases run peak period peak direction only. In the **active modes** quadrant is walking, which with minimal infrastructure and a very small footprint represents the most efficient way of travelling. Cycling is also relatively spatially efficient, and bikesharing exists in the public quadrant since sharing allows their use through successive points in time hence making them more temporally efficient.

At the centre of the **private modes** quadrant is the private car, which performs poorly in both spatial and temporal dimensions, typically averaging just 1.2 people per vehicle for journey-to-work travel and sitting idle around 95 percent of the time.[10] Ridesharing (or carpooling) remains privately owned but being shared occupancy is more spatially efficient. The **shared modes** quadrant is dominated by new mobility services led by TNCs—joining the previous incumbent conventional taxis (and shared taxis in cases where they exist)—being temporally efficient but not spatially efficient. Ridehailing and shared ridehailing fit on the same spatial efficiency as taxis and shared taxi, but are less temporally efficient, since they are often a side-job for drivers, as compared with taxis which are driven by professionals with vehicles often working multiple shifts. Other emerging modes straddle the private and shared quadrants. Carsharing is sole occupancy but better utilised temporally when fleet managed than peer-to-peer, since in the latter there are more transaction costs (e.g., screening, less convenient positioning) so can be expected to be utilised less extensively. The efficiency of autonomous cars depends on the ownership model, but all are less spatially efficient than manually-driven automobiles to account for the time spent repositioning with zero occupancy. Autonomous taxis operated as part of a fleet are more temporally efficient than under an own and share model which in turn performs better than privately held cars. When autonomous vehicles are used to pool trips together amongst a number of travelling parties, their spatial efficiency improves.

We believe our concept of spatial and temporal efficiency ought to be an overriding criterion for transport policy. We note the limitations to this construct—for example, in terms of temporal efficiency, it is a greater problem for an expensive train to be idle than it is for a cheap bicycle (the influx of shared bikes in many urban areas confirming this to be less of an issue). The model, however, offers a powerful visual representation in terms of the spatial-temporal mix and link to policy setting desired. It also underpins our speculation as to how a future MaaS model might look in terms of its mix of modes (Fig. 3). We believe how the MaaS model may look will critically depend on the culture into which it is introduced. Taking two extremes, on the one hand we can consider what we identify as private car *first* cities (1A), such as in North America or Australia, where private car enjoys the vast majority of mode share and the travel patterns are centred towards the bottom left quadrant; and public transport *first* cities (2A), such as in Asia and to a lesser extent Europe, where public transport is the norm and the geared towards the top right quadrant.

With the influx of shared modes and autonomous vehicles coming online, we can envisage different MaaS schemes coming to fruition. Fig. 3 shows diagrammatically the predominant modal efficiencies in terms of their spatial and temporal efficiencies. In private car *first* cities which are auto-centric as shown by Fig. 3(1A), public transport is unlikely to start playing the major role in the development of MaaS, although supported by shared modes may make public transport more palpable for users. In these cities, point-to-point modes will remain important, though potentially accessed more widely in the form of carsharing. MaaS products might even

[10] We recognise there may be contextual differences, but these are generally-cited ballpark figures in developed Western economies.

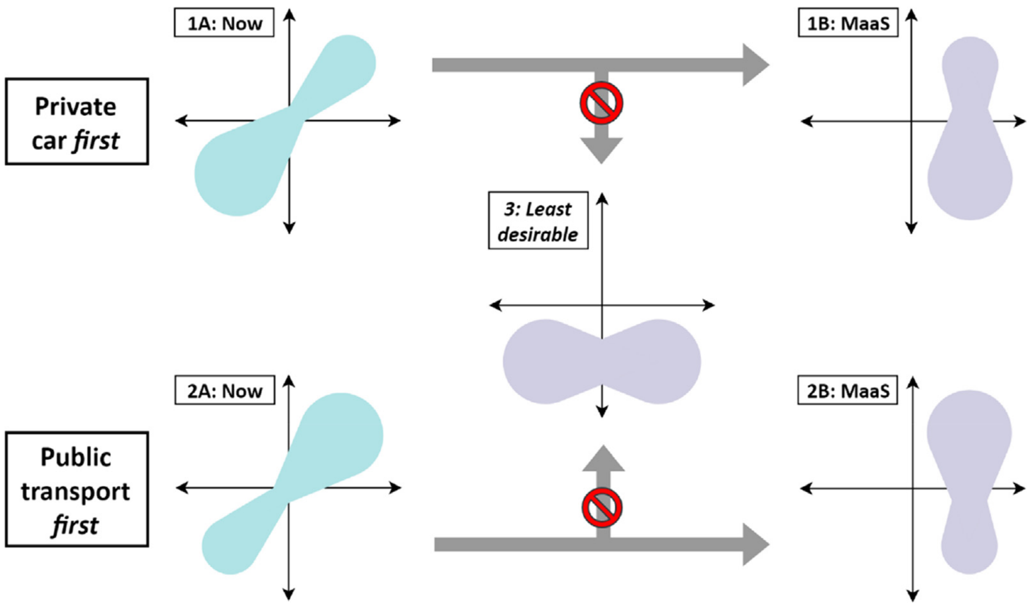

Fig. 3. The modal development framework which envisages how MaaS might look in terms of the centre of mass of modes (as defined by their respective spatial-temporal efficiencies) in both (1) private car first and (2) public transport first cities. A third (3) least desirable future is described which we assert ought to be avoided.

include parking elements to support such modes. Fig. 3(1B) shows the shift from now until when MaaS is implemented. The greatest challenge is in moving private car owners onto shared modes, and this might include targeting families' second cars initially—including those who use their own vehicles only on weekends and those using cars exclusively as an access/egress mode for public transport. These potential market segments are explored in Ho et al. (2018). Rural and regional environments will also situate here where space is more readily available and so may accommodate a greater mix of point-to-point offerings using less spatially intensive modes. In contrast, in public transport *first* cities, where the modal efficiency is characterised by Fig. 3(2A), there is a real risk that existing public transport users will shift onto more personalised shared modes previously only available as taxis as shown by Fig. 3(2B). MaaS products must hence not encourage such shift in behaviour. Importantly, MaaS is not designed to replace many of the significant high volume and high capacity services in megacities where the backbone of the public transport system is heavy rail. In this context, MaaS at best may be a supporting mobility tool to enable improved access and egress (i.e., first and last mile) to these high-volume systems. Vehicle licensing rates are already much lower and so it is unlikely that carsharing or private vehicles will become of great importance—although in an autonomous world this is far from certain. In both cases, the least desirable outcome Fig. 3(3) sees public transport displaced and MaaS products comprised of the least spatially efficient modes. The preceding two scenarios in terms of modal displacement and modal convergence both constitute a centre in the bottom right shared modes quadrant. We must therefore consider at a strategic level exactly how (1B) and (2B) might be implemented, again in terms of the two dimensions space and time.

4. Improving modal efficiency through MaaS

In both private car *first* and public transport *first* cities, MaaS brings together all temporally efficient modes across a range of spatial efficiencies. The question, therefore, is how best to integrate across these spatial scales and deploy the most appropriate mode in each spatial-temporal setting. This necessitates a re-evaluation of transport integration. Whilst there exists an abundance of literature on the integration concept (Chowdhury and Ceder, 2016, Mulley and Moutou, 2015, Preston, 2010, Grotenhuis et al., 2007)—and mainly around public transport modes in isolation without regard for emerging mobility services or indeed private modes of transport—we are unaware of any framework which captures both spatial and temporal dimensions as the conceptual basis for this integration. Modal integration will help ensure that the transport system is network-wide efficient, not just efficient within each mode or operator.

4.1. Spatial integration

The spatial performance of each mode ought to be related to the spatial intensity of land use where it is deployed. In denser environments, there is greater pressure on road space and thus more spatially intensive mass transit modes are necessary. Land use policies should also encourage active travel. Conversely, suburban environments necessitate greater point-to-point transportation due to the sparser land use patterns. The divide exists not only between land use types but also between types of flow. Radial flows to the urban core or central business district are high in volume and suited for high capacity public transport whilst orbital travel is more diluted and generally requires less spatially intensive modes. In more mixed use Asian/European settings there would be a hybrid state of play. These are tested concepts and indeed there has been a trend towards tiered bus networks (e.g., rapid, suburban, local) where services are consolidated on major corridors, accompanied by a higher level of service through increased frequency and speed (Nielsen et al., 2005, Walker, 2008), thereby further exacerbating the first and last mile challenge. New shared modes may be used as part of a trunk and feeder system to feed thriving arterials and dense locales, deployed where there is a cost advantage and geographic impetus for such services.

A choice may continue to be offered for customers who prefer single-seat rides, but it must be priced in such a way as to appropriately trade-off between the spatial-temporal characteristics of different modes. The main rationale for this is because modes of different spatial intensities perform differently as demand grows. For public transport on dedicated right-of-way, crowding manifests, thereby reducing the road space per passenger but in general maintaining travel time consistency. The converse is to hold road space per passenger constant (as in the case of private cars and valued as 'comfort'), but then there is a temporal trade-off as journey time and reliability begins to suffer. The right policy settings can help improve the mix and ensure that those who value space pay for it, whilst those who value time are afforded that certainty. Spatial integration is an enabler for this vision and ought to be a key characteristic for MaaS in the future.

4.2. Temporal opportunities

Whilst trunk and feeder systems constitute a spatial integration of public and shared modes, there also exists the opportunity to integrate across the temporal dimension of transport service provision. All modes of transport seek to meet peak demand (Walker, 2012), when roads are most congested and public transport most crowded. For public transport agencies, peak demand defines vehicle requirements, vehicle capacities as well as staffing levels (Vuchic, 2005). Peak transport costs are highest as these additional vehicles are procured and personnel employed to service peak periods exclusively (De Borger and Kerstens, 2007, Walker, 2012), sitting idle and unproductive at other times of the day.[11] There exists a significant negative correlation (Nolan, 1996) between the peak-to-base ratio[12] and technical efficiency in the use of resources, through impacts on service scheduling (Iseki, 2010, García Sánchez, 2009). The temporal efficiency of public transport as defined in the modal efficiency framework is hence a function of its operational peak-to-base ratio, with temporal integration between public and shared modes offering the potential to further enhance temporal efficiency—a dimension often neglected in the transport integration and MaaS literature.

There is again a link to the South African minibus taxi experience, which in many cases compete on the road with new bus rapid transit systems, despite having been compensated by government to exit the market (Behrens et al., 2015). These illegal entrants operate essentially as a top up service on the bus rapid transit base load, [13] representing a form of temporal integration and saving 30–40 percent in peak vehicle requirements (personal communication with City of Cape Town, 14 February 2017). In a similar fashion, digitally-enabled shared modes can provide a top up service to the conventional public transport base load in developed economies (Fig. 4), saving peak service costs.[14] One weakness with this model is that it outsources the most expensive (peak) service to independent contractors, bringing potential issues in the social dimension. Work has also been done plotting the distance decay function for temporal variation in transit patronage—namely, how the patronage peak-to-base ratio varies with increasing journey distances (Wong, 2015). This suggests that there are particular geographic contexts where this model of temporal integration is most applicable and useful for maximising urban efficiency. Temporal variation also exists across other scales including seasonally (winter/summer and in particular school holidays) and interpersonally. Specific vehicle types might be required for particular trip purposes (consider journey-to-work versus shopping or a road trip), and the opportunity under MaaS is to effectively allocate to demanders based on transport needs from amongst a smaller total fleet pool through a centralised coordinating entity.

5. Service delivery models for MaaS

5.1. Mobility ecosystem

Spatial and temporal integration constitute key components of our MaaS vision where MaaS is an enabler of an efficient transport network. The potential role of MaaS in this new paradigm must be operationalised by a service delivery model which brings together a range of actors. There are different available alternatives for this MaaS ecosystem, but each differs significantly from the status quo in terms of how public transport has traditionally been delivered (Fig. 5). Model A represents the present paradigm[15] where the government (regulator) contracts suppliers (operators) to deliver public transport services for demanders (customers). Implicit within

[11] Note that some peaking is required to allow a rotating subset of vehicles to be maintained/cleaned.

[12] Defined as the quotient of peak vehicle requirements and vehicle requirements in the inter-peak (usually calculated at midday).

[13] This compares with the traditional model where minibus taxis service the base load and conventional buses provide the top up (forced out due to taxi violence and intimidation), completing perhaps two trips per day and representing a very poor utilisation of resources.

[14] See think piece on MaaS and the modal capacity shortfall: https://sydney.edu.au/business/news-and-events/news/2017/08/31/mobility-as-a-service-and-modal-capacity-shortfall.html.

[15] Models of economic deregulation (competition *in* the market) as exists for the bus sector in the United Kingdom outside London and New Zealand (as examples) are not illustrated in this case.

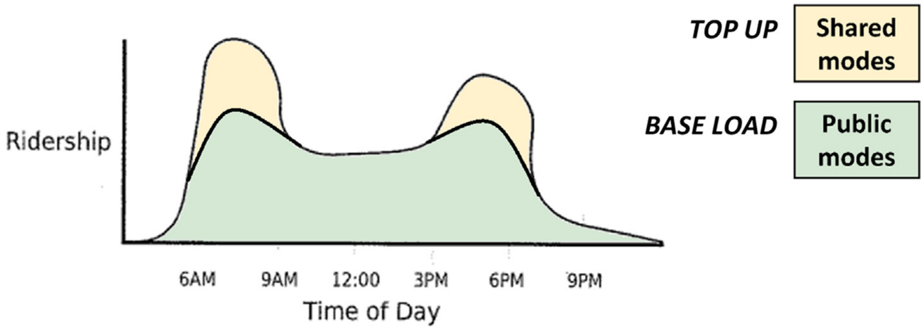

Fig. 4. Potential model for temporal integration between public transport and shared modes, based on the minibus taxi and bus rapid transit integration experience.

this model are suppliers competing *for* the market (either through tendering or negotiation) to win service contracts from government. Conversely, the demander pays fares to the supplier who meets key performance indicators as stipulated in their contract to government. The blue overlay represents a blur in boundary to include the instance of a government supplier—that is, where public transport services are delivered by a government operator (either a government department or agency) with no transfer of risk to the private sector.

To deliver MaaS, a number of specialised businesses must be brought together, which we define as **mode-specific operators** or incumbent providers of passenger transport service (bus, rail, TNCs, etc.) and **non-mobility providers**, which captures new entrants like vehicle manufacturers, technology providers and financial enterprises. Interested parties and the conditions around which they might invest or supply in a new entrepreneurial model, facilitated by mode-agnostic mobility contracts are investigated in related research Wong et al. (2018). In this study a candidate sampling frame was defined in terms of jurisdiction, market sector and position level. The jurisdictions of Australia, Hong Kong, Singapore, Japan, Western Europe and the United States were selected as the sampling frame due to similar perspectives on risk and investment, and a level of dialogue and engagement between these economies. The organisations selected were categorised under mode-specific operators (incumbent providers of passenger service) and non-mobility providers (new entrants) interested in partaking in the MaaS business model. Mode-specific operators include public transport operators, taxi operators, transportation network companies, carshare operators and bikeshare operators. Non-mobility providers comprise of vehicle manufacturers/suppliers, technology providers/start-ups, financial enterprises, infrastructure operators, property developers, telecommunications providers, consultancies, insurance companies and industry bodies. Senior executives making investment decisions within companies in the market sectors of interest were targeted and invited to participate in the online survey. A total of 202 responses were collected between May and October 2018, with a roughly equal mix of mode-specific operators and non-mobility providers. More details are provided in Wong et al. (2019).

The design and implementation of MaaS is described in Hensher (2017) as being related to the *three Bs* budgets, bundles and brokers (aggregators). In Models B and C, we introduce a new business entity that is the MaaS **broker/aggregator** (*third B*) and situate it within a blue box in the diagram because incumbent suppliers of transport services can also take on this broker role. Mobility brokers purchase the transport asset/capacity from a number of suppliers (including those providing investment, expertise and service) and integrate them as mobility plans or packages for demanders to subscribe. Subscription packages, in contrast to pay-as-you-go, may not necessarily be the preferred mobility delivery mechanism in the future but it is presently of interest as the market and researchers explore possible ways of delivering MaaS.[16] We may, for example, simply see an aggregator providing a one-stop multimodal application and nothing else with costs covered by advertising and the like. There are many unknowns and what eventually develops remains to be seen. Regardless, the MaaS broker adds value by bringing that integrating function as part of their service offering. The relationship of this broker situated amongst other actors including government is explored in our two proposed models for the MaaS ecosystem.

5.2. Free market operation

One major question concerning candidate actors is the role of government in an emerging MaaS future. Whilst some advocate for a government agency or quasi-government entity (including a public transport authority) to assume the broker role (Kamargianni and Matyas, 2017), others have found amongst a Delphi study of experts that transport operators are the preferred service integrator, followed by a third-party mobility provider (Jittrapirom et al., 2018). Whilst we acknowledge that the public sector should have an important role to play in encouraging innovation in the market and indeed contributing where appropriate itself, there is strong support from the private sector to rely on private equity with appropriate regulations in place to encourage private sector activity.

Nevertheless, in many countries the move from public monopoly delivery of public services in the transport sector to mixtures of economic deregulation and competitive tendering with a greater involvement of market forces and private operators has had a

[16] A two-year (2019–2020) MaaS trial is in place in Sydney, coordinated by ITLS and working with a large insurance company and a start-up application developer.

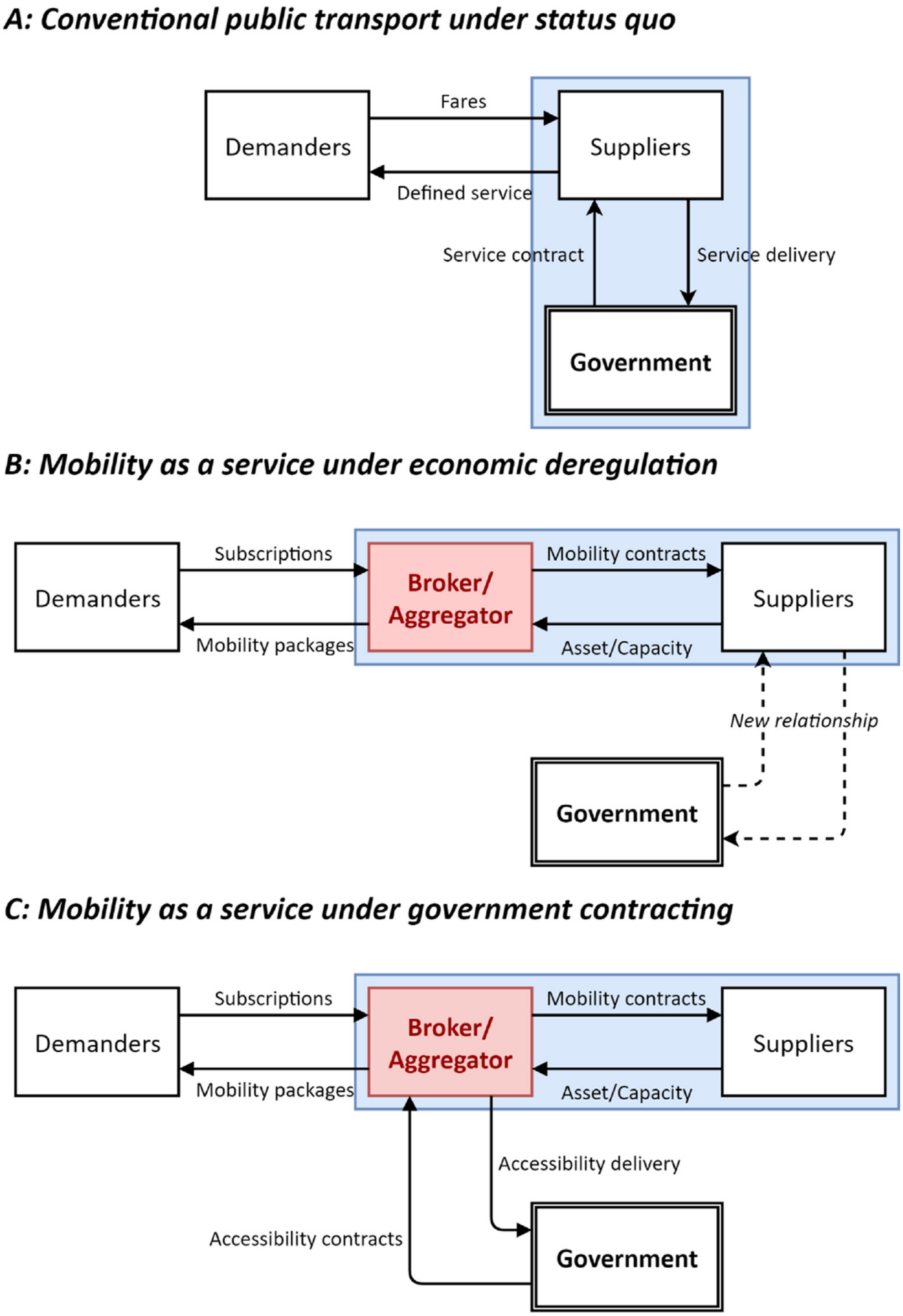

Fig. 5. The present service delivery model for (A) conventional public transport under the status quo (of government contracting), and proposed framework for the MaaS ecosystem, comprising the new function for a mobility broker/aggregator, operating under (B) economic deregulation and (C) a government-contracted scenario.

chequered history. While there have been successes, mainly through competitive tendering (and rarely through economic deregulation), the lessons learnt may be valuable as to how the MaaS model may evolve through time. A number of governments (for example, in Australia) appear to be keen at present to encourage start-up companies or even established businesses to take on the role of a broker in testing the potential for a MaaS service model. However, other countries prefer to have greater control through a public sector led initiative of participating in the delivery of multimodal MaaS services (partnering with private sector TNCs such as Uber[17]). The latter is especially true where traditional public transport remains in the hand of the public sector. We believe that the jury is still out on this and lessons will inevitably be learned through time as to the preferred roles of public and private agencies and what this might mean for overall service efficiency and any risk of anti-competitive behaviour and discrimination favouring specific modes in the MaaS modal mix.

We therefore believe a government broker is a particularly challenging proposition since they might not only lack the incentive to innovate but also cause a potential conflict of interest, especially in cases where both public and private operators exist. Conflicts of interest may also exist between multiple private operators. Increasingly amongst Western economies, governments are removing themselves from a service provision role, but rather being involved at arm's length only (Wong and Hensher, 2018). With the advent of TNCs, decision-making has largely shifted from public authorities and public investments to private companies and private investors, though government is now pushing to regain oversight of the system—for instance, by capping the number of dockless bicycles, designating virtual docks, charging ridehailing surcharges and running accreditation schemes for TNC drivers. This direction includes the Nordic countries which removed all mode-specific regulation to welcome MaaS but now government realises that it has lost control of the customer! However, there remains no evidence that government wishes to run the entire mobility system. We hence assume a private entity broker in our proposed models for the MaaS ecosystem, despite many governments and public transport operators supporting MaaS trials.

The present handling of TNCs and the shared mobility services they provide is akin to an economically deregulated market which we can assume initially for MaaS (Model B). In this scenario, government can only influence MaaS operators at the margins, specifying the conditions and barriers (or lack thereof) for market entry but otherwise it is a market driven scenario including any impacts on modal shift, congestion (see Erhardt et al., 2019), data sharing/exchange and the economy. In this policy 'vacuum', MaaS actors are motivated by the commercial imperative which may or may not align with government objectives for transport and land use. Government will forge a new relationship with existing transport operators in this instance, including reforming present mode-specific, area-based contracts, given this new focus on MaaS (Hensher, 2017). Incumbent mode-specific operators might no longer be bound to a single customer (the government authority—as a monopsony at present), but rather, operate in a more competitive mobility environment, but one with greater opportunities and potential.

A number of risks might entail in this instance. For instance, monopolistic and predatory behaviour from larger brokers/suppliers, similar to the way in which larger bus operators were able to push out smaller players in the deregulated British bus market (Dodgson and Preston, 1991, Preston, 1992), may lead to an undesired market consolidation. Closed, proprietary platforms (just like in the bus industry their reluctance to introduce smartcard ticketing) are symptomatic of this development and industry associations like MaaS Alliance[18] are working to maintain open and common standards of operations. This will also allow the roaming of MaaS products across jurisdictions—a big part of the promise. Secondly, we note that shared mobility services are usually more lucrative and operate with higher margins (profits) than heavily subsidised public transport operators whose businesses are generally very marginal. In a free market environment, this will likely affect the modal mix in terms of MaaS bundles sold to the public and how they are priced. There may be a financially-driven impetus to substitute customers away from public transport towards less spatially efficient modes. This contravenes the ideals and framework set out in this paper. In Wong et al., 2019, we have been testing whether this might be the case in terms of the modal mix candidate MaaS actors are willing to support. We also wish to understand how different modal operators might support different modes since those most interested in MaaS might play a big part in determining what eventuates as the modal mix.

These sorts of commercial and strategically-driven decision-making are rarely consistent with the urban efficiency goals of cities. It is necessary to determine what kind of equilibrium is being set by the market then approach with a critical eye as to what is necessary to control for any unintended consequences. One 'light touch' approach in this future might be to move from self-regulation towards government acting as an independent regulator, similar to the Office of Rail and Road (ORR) and the Water Services Regulation Authority (Ofwat) in the United Kingdom, to define conditions around safety and fair competition in the MaaS marketplace. An alternative is a government-contracted MaaS model where the authority can set all the parameters of operations consistent with societal objectives.

5.3. Government-contracted model

Around the world, the trend over the past 30 years has been to welcome greater market initiative to combine the best elements of competitive tendering and economic deregulation (Wong and Hensher, 2018). This next generation service delivery model bodes well with the shift in public transport contracts from their present output-based form (delivering kilometres on defined modes) to

[17] Uber is an example of ridesharing which will likely form a constituent component of MaaS. The focus of MaaS, however, is on a multimodal model with an important objective being to reduce private car use and ownership. Switching from private car to public transport as part of MaaS is desirable, and can be supported by higher discounts (or other incentivisation models) on public transport provided through MaaS.

[18] For more information, visit: https://maas-alliance.eu.

outcome-based models which seek to deliver *accessibility* using any mode—thereby becoming truly mode-agnostic (Hensher, 2017). We envisage a government-contracted MaaS model (Model C) that delivers on autonomous market freedoms whilst maintaining strong regulatory control and oversight. In this proposal, the government directly procures a mobility broker through a competitive tender, with the opportunity to negotiate contract renewal (under actionable benchmarking) at subsequent rounds once the market has matured.[19] The move to outcome-based contracts will mean more complex performance measures (e.g., related to customer accessibility rather than vehicle kilometres) but developments in technology is fast making this possible. Under the terms of the contract, the government sets accessibility standards, which might be defined as delivering *X* percentage of people services within *Y* minutes, for a given period using any mode of the broker's choosing. Rather than delivering defined kilometres on regulated modes, the broker can operate or subcontract ridehailing and microtransit in the suburbs, which feeds seamlessly with high priority mass transit to the urban core—itself topped up with point-to-point service which is priced at such a premium that demand does not inundate the network. To maintain the full range of service offerings across spatially efficient modes and for transport equity considerations, internal cross-subsidisation is encouraged (which is already a challenge for some participants in the MaaS aggregator model) and there exists also the prospect of financial support from government to meet any funding gap required to deliver.

One of the most promising opportunity under a contracted MaaS model is the ability for government to regulate for network efficiency by incorporating a road user charge as an input into package price. Whilst road pricing has been on the agenda since the 1960s, there has only been limited implementation around the world (Verhoef et al., 2008). Both cordon-type charges (e.g., in London, Stockholm, Singapore) and road tolls (e.g., public/private motorways in Sydney, Johannesburg) constitute flawed systems which distort the market rather than maximising for network efficiency. There has been a lot of work in recent years around road pricing buy-in (for both politicians and the public)—including opportunities for the hypothecation of revenue streams, and phased implementation starting from opt-in distance-based registration fees (Hensher, 2018; Hensher and Bliemer, 2014; Hensher and Mulley, 2014). MaaS, in bringing together *all* modes of travel, offers a 'big bang' approach in allowing an easily implementable digital system which can price according to time of day (to the minute), geography (by location and road type) and modal (both spatial and temporal) efficiency. Additional inputs like environmental considerations (vehicle emissions) and subsidies (means-tested for social inclusion) could also enter the fore here, linked to the zero-tariff concept. A clearing house mechanism like that used in other utility markets can determine in real time the price for a particular trip. There can also be a hefty surcharge levied for zero-occupancy vehicles to discourage such type of travel behaviour, as well as other occupancy-linked charges in the same way that individuals pay fares on public transport. The temporal mode price favours fleet managed systems over peer-to-peer and private ownership, with links to sustainability as well as freeing up road space occupied by parked vehicles.[20] This space-time road price has, in the longer term, links to location choice including where people choose to reside and work, thereby helping move cities towards more sustainable and compact forms.

We recognise there are some limitations to this bold, radical idea (although for the first time the emotional debate on road pricing can be removed as it becomes simply a component of the subscription price)—scalability is a real challenge as is political 'buy in'. Regulation is often synonymised with stifling innovation and market agility, but it also creates a level playing field for progress, as has occurred in the telecommunications sector and provided the regulator is not 'captured' in the process. Regardless, any form of impedance will likely bring huge benefits in terms of smoothing travel peaks, reducing congestion, and bringing about greater travel time certainty. The flow on effects of this will bring enormous benefits to a multitude of other market sectors which depend on an efficient mobility system. Of course, this whole idea is premised on all people consuming a considerable proportion of their transportation through MaaS. However, it may turn out that this is not the case and MaaS is only a niche product in which case MaaS as a demand management concept becomes more difficult to envisage. Those who use public and shared modes exclusively will simply have the network charge hidden as an input into the total package price—invisible to the end user which we find is crucial in garnering stakeholder support. People who continue to own private cars might also participate by paying a marginal rate of use (if reforms can be achieved), otherwise in the interim through variations in registration, taxes and other charges. There can be a multitude of MaaS operators in this landscape, but as a condition of operation they must vary prices according to the network charge stipulated by a body independent of government.

6. Conclusion: Visions for the future

In this paper, we have presented our concept of modal efficiency and explained why it ought to be an overriding criterion for transport policy, used both in evaluating the potential unintended consequences of emerging mobility services and technologies, as well as to design our vision for how MaaS might work to societal advantage rather than just as a new technology or product. Our proposal is closely linked to the regulation of autonomous vehicles as they come online, as well as the geometric realities of cities as dense urban environments which TNCs and technology players ignore too often. One of the major misnomers is the idea that pooled vehicles and door-to-door service can concurrently exist. Point-to-point transportation is by definition low volume and associated with sole or low occupancy vehicles which should be limited in sustainable, compact cities.

[19] A tendering model allows for the efficient selection of a MaaS broker/aggregator, especially important in the context of any government subsidies outlaid. In related ITLS research, we have found that private companies prefer the suggested free market scenario operating at arm's length to government (with their strategic support and ensuring a level playing field) rather than being necessarily subsidised (where effectively government becomes their single customer) and having government meddle in the affairs of the business.

[20] Parking charges may also be included as part of a MaaS package and thus no longer required as a standalone system.

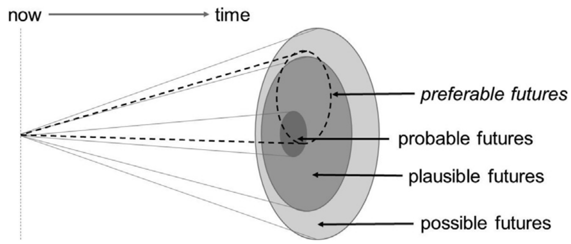

Fig. 6. The futures cone typology as described and adapted from Hancock and Bezold (1994) and other work.

Looking forward, we can draw upon (as a schematic) the futures cone typology (Hancock and Bezold, 1994) to illustrate a diverse range of future scenarios (Fig. 6). The universal set of **possible** futures encompasses everything that might happen, and includes the extremes of modal displacement (the wholesale demise of public transport) and modal convergence (to an automated taxi service) illustrated in this paper. The exclusive use of these spatially inefficient modes will worsen congestion and exacerbate urban sprawl. **Plausible** futures describe a subset of this, referring to what could happen based on current knowledge. This includes futures where modal displacement or convergence eventuate in certain contexts or cities. Extrapolating the baseline reveals a default 'business as usual' **probable** future. In this world, MaaS might work in conjunction with existing modes of transport, but can only shape behaviour at the margins. MaaS operates in the free market, and brings a number of unintended consequence for cities. This is also where our definitional gap arises in terms of whether MaaS constitutes a product or a vision, as described in our value judgement **preferable** future. In this alternative, all people access transportation as a service, whether they be public, shared or private modes. Spatially-efficient modes remain a crucial component of MaaS schemes, and are deployed as the first preference wherever possible. Modes which are inefficient in terms of space or time are penalised through price or consume more credits within mobility packages. We price modes to reflect an efficient use of the road network with the now added opportunity to embed a reformed road user charging scheme within the MaaS subscription price that removes the emotional position whenever governments propose an externality charge such as a congestion charge. In this world, MaaS is more than a user-centric digital interface platform but also a mobility management tool used to optimise the urban realm—to the extent that optimisation is possible, given that it may be a compromise solution (or second-best solution) with other markets being influenced adversely. This preferable future is far from guaranteed, and requires conscious policy directives to realise.

Looking back through transportation history, there have been clear instances where humanity has let a probable future run its course and were either caught unaware or without the foresight to alter its trajectory. For instance, the air pollution, waste products and health implications of horse-based transport were replaced by more virulent externalities as combustion-engine motor vehicles came into being (Morris, 2007). Karl Benz and Henry Ford brought the world (despite great benefit!) universal car ownership and oil dependence, with implications for health and land use in facilitating urban sprawl. Had history taken a different tack we might be living in a very different world indeed. Whilst we do not argue that cars do not constitute progress, E. H. Carr's adage "change is certain, progress is not" rings true. The challenge, we believe, is to garner the enabling role of technology to disrupt the transport system for our advantage (Mulley, 2017)—that is, societal, not commercially-driven goals. Government-contracted MaaS, with its institutional overlay and road user charge as an input into package price can help deploy the most appropriate mode for each geographic environment (informed by the modal efficiency framework), thereby maximising urban efficiency for a societal equilibrium. The proposition that has been put forward requires proactive policymaking that can guard against policy failure through adaptability to unanticipated change (decide and provide). Charting a course through this territory is of course highly challenging but may be informed by research.

This overview paper has raised a number of fundamental issues for which additional research is required and which more evidence is provided in this Special Issue. We need to quantify what commercial interest there is in the MaaS business proposition both under a free market environment and with varying levels of government intervention. This will likely depend on the mix of actors, including mix between mode-specific operators and non-mobility providers. The merits of partnerships with government including the impacts (positive or negative) of public transport subsidies are also important. Finally, issues of (un)fair competition between and amongst market players must also be considered. These broad questions support an open agenda of research into the supply-side of MaaS. The present authors are tackling some of these unknowns through a program of work (Wong et al., 2019) to establish the criteria as defined through a range of attributes which drive candidate businesses to either invest or supply in the MaaS entrepreneurial model. Advanced stated choice techniques are being used to test alternative business models, including a mix of service offerings and government involvement, and design mode-agnostic mobility contracts in an attempt to inform the likely new futures for service delivery which might emerge. With greater certainty, government can appropriately evaluate the marketplace and design the necessary regulatory structures and other policy measure to guide market forces and secure the desired, *preferable* future for society. But in the end, we believe that the only real test to establish the future of MaaS is through real market trials (Smith et al., 2018a), informed we hope by some of the research presented in this Special Issue on developments in mobility as a service (MaaS) and intelligent mobility.

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