IATSS Research 43 (2019) 219–225

Contents lists available at ScienceDirect

IATSS Research

Overview

The shape of MaaS: The potential for MaaS Lite

Andrew Pickford [a,*], Edward Chung [b]

[a] Transport Technology Consultants, Causeway Bay, Hong Kong
[b] The Hong Kong Polytechnic University, Kowloon, Hong Kong

ARTICLE INFO

Article history:
Received 9 October 2019
Received in revised form 21 November 2019
Accepted 25 November 2019
Available online 6 December 2019

Keywords:
Mobility as a service
Mobility on demand
Demand responsive transport
Integrated transport
FMLM
Interoperable ticketing

ABSTRACT

Mobility as a Service (MaaS) is about improving mobility for people. Since Gothenburg piloted the first multi-modal Mobility as a Service (MaaS) scheme from 2012, there have been many further attempts at introducing connected and bundled services globally, invariably provided as a mobile app and a single, simple ticketing interface. As in any emerging paradigm, the varying flavour, or 'shapes' of MaaS that are piloted reflect the search for a sustainable business model and connectivity between transport operators at varying levels that includes risk re-allocation and data sharing. The varying levels of success of MaaS and Mobility on Demand (MOD) lead the authors to propose *MaaS Lite*, which reflects an incremental approach to MaaS based on a simpler organisational arrangement that does not depend upon the introduction of a Mobility Operator as a new player. *MaaS Lite* also recognises that most trips are not complex at all, often based on one or two connected mechanised modes that meets highly local needs, including FMLM service connectivity.

Overall, MaaS is not a 'one size fits all' solution for all regions but the benefits of the highly targeted *MaaS Lite* could realise early public benefits as a first step in the development of a multi-phased 'services road map' that evolves towards the implementation of multi-modal, region-wide operationally integrated MaaS. Case studies in Hong Kong and Brisbane demonstrate the merits of *MaaS Lite* in these two contrasting environments having different regulatory regimes, population densities and levels of private car ownership.

1. What is MaaS?

Mobility as a Service (MaaS) is about improving mobility for people. Transport is the means to an end, and not the end in itself. MaaS refers to the re-orientation and repurposing of the transport systems around users' needs – from one end of the trip to the other, whilst improving accessibility and without compromising equity or levels of active mobility. There have been many different opinions on what MaaS is, and since the world's first commercial pilot of Maas in Gothenberg from 2013–2014, there have been as many different services propositions described as MaaS.

The UK-based Institution of Engineering & Technology (IET) defines Mobility as a Service (MaaS) as "*The provision of an end-to-end customer experience that delivers multimodal transport choices through a seamless and integrated planning, payment and ticketing interface*" [1]. Potentially, MaaS can enable operational integration between mode providers and is often associated with novel approaches to payment by allowing users to pay per trip or a monthly fee for a capped limit on distance travelled.

However, there are probably as many definitions of MaaS as there are pilot schemes globally. This is probably the result of rapid evolution, the continued search for (and competition between) business models, power balance between stakeholders, degree of private sector participation, and local regulatory provisions. The on-demand shuttle service *Kutsuplus* (lit. 'Call Plus') that was launched in Helsinki in 2012 by the Helsinki Regional Transport Authority (HSL) claimed that: "*Public transport of the future [would be] so smooth and flexible that you might never need to buy a car of your own*" [2] and recognition that such a new approach was needed was also articulated by Alto University in 2014 [3]. Although only one mode of transport was offered, *Kutsuplus* had tested one potential business model for demand responsive public transport although achieved insufficient scale for fares to be competitive, and the service was terminated in December 2015 [4]. In parallel, a pilot multi-modal scheme commenced operation in Gothenburg later in 2012 that was branded *UbiGo* represented the world's first demonstration of MaaS. This scheme was based on a centralised structure and it was offered to 83 households (195 individuals) for a fixed monthly subscription.

Notably, the *UbiGo* pilot was unable to transition to a commercial structure due to "*various institutional barriers*" relating to ticketing and organisational roles, and the finding of the study was that any future

* Corresponding author.
E-mail addresses: andrewpickford@ttc-global.com (A. Pickford), edward.cs.chung@polyu.edu.hk (E. Chung).
Peer review under responsibility of International Association of Traffic and Safety Sciences.

https://doi.org/10.1016/j.iatssr.2019.11.006

implementation should focus on "*rules and regulations, models, organizational culture [and] consumption patterns*" [5]. The Gothenburg pilot was concluded in 2014 and relaunched in Stockholm in May 2019 combining public transport, car-sharing, rental car services and taxis. As in the initial trial, accounts are allocated to households rather than individuals.

One of the goals of MaaS is to shift travellers away from personally-owned modes of mechanised transport, which is likely to require, as a minimum, a comparable level of convenience. MaaS also aims to bring together every kind of transport mode, including walking and, where available, cycling, into a single intuitive service and an ongoing payment subscription, analogous to the purchase of other bundled services such as broadband TV or mobile phone-related services. Bundled services are often based on a monthly subscription that reflects an agreed level of consumption, such as minutes of airtime provided by Mobile Network Operators or expected data rates delivered by broadband service providers. In addition to tiered charging at different levels of consumption, the business case for any further differentiation has proven historically challenging.

Arguably, the provision of transport services offers a basis for highly diverse sources of services differentiation such as the travel distance to the point of pickup, the time of departure from that desired, quality of mode transition, vehicle ambience and an acceptable Estimated Time of Arrival (ETA). Metrics such as travel time, the variability of travel time, the cost and carbon footprint could also inform user choice. The challenge is do this using different modes, either a single mode if this would be most appropriate, or multiple modes that are operationally connected to deliver a single, coherent and predictable journey for a user. This must be done despite the fact that each mode has different characteristics such as capacity, flexibility, cost (to the user) and carbon footprint. A focus on commoditised modes accessed from multiple providers, also providing goods transport to meet a limited set of user requirements, is sometimes referred to as Mobility on Demand (MoD) [6] which aims to offer route flexibility and bridge geographic gaps in the provision of public transport by extending the coverage and service times of transit services although without integration amongst them. Notably, one MOD services in the UK failed, with the claim that "*microtransit services in large city centres can only operate smoothly when they are fully integrated with the public transport network*" [7]. Similarly, in the US, MOD suffers from the comparative "*geometric efficiency of fixed route services*" [8] amongst other reasons [9]. The latter also highlights the difference between MOD and MaaS, in that MaaS is aimed at replacing, in part, the convenience of personal transport such as taxis and private cars that are invariably priced at a premium to public transit on which MaaS is largely based.

In the authors' experience, a resulting lack of scale, poor (or no integration) between modes, institutional barriers, resistance to changes in the allocation of risks (and related profits) between operators, poor marketing, inflexible regulations, uncertainty over the role and wariness of the impact of innovation have been evident to varying degrees in attempted MOD and MaaS implementations in the US, Europe and Australia. However, the number of failures has been matched by successful implementations of MOD, including New York, Chicago and Boston, whilst Stockholm is joined by pilots of MaaS in Birmingham, Singapore, Vienna and more recently Berlin, (potentially) Europe's largest MaaS scheme.

2. MaaS and the transport hierarchy

Fig 1 highlights the inverse relationship between flexibility, demand-responsiveness and capacity, define each mode in the transport hierarchy and provide the services platform on which MaaS is based. This figure highlights the inverse relationship between capacity and flexibility.

The choice of modes in any MaaS scheme will vary from one or many of these, depending on location and affordability. A typical trip may be based on 2, 3, or 4 of these modes (including walking) and of equal importance is the quality of the transition between them. In the context of a choice of modes, to deliver the benefits of a user-centric, multi-modal approach to the delivery of mobility services, we propose a more focused and deliverable model known as *MaaS Lite* that overcomes many of the most significant barriers to implement MaaS, namely institutional inertia, poor scalability and lack of trust amongst operators and users.

Our hypothesis is that an incremental approach to MaaS, that starts with an initial phase that we describe as *MaaS Lite*, is better able to focus on the user-centric service aspects of one mode within the context of others, can deliver higher quality public benefits earlier, affords high level of convenience, presents a lower risk entry point to users and is less subject to institutional barriers that would be evident in aiming to implement a more complex MaaS scheme initially. Essentially, with the definition proposed here, *MaaS Lite* encourages an early focus on 'the user' and 'the end-to-end trip', as a starting point for a services roadmap to more advanced and pervasive MaaS scheme ultimately extending to operational integration and an open ecosystem enabled through standardised interfaces with operators.

MaaS Lite is the first step within a well-defined travel corridor or area towards the managed transition towards a more comprehensive large area MaaS scheme. An incremental approach to the introduction of demand response transport had been suggested by others as early as 2006 [10] but the recent lessons highlighted above now permit such an approach to be validated, introduced herein as *MaaS Lite*. Conceptually, the domain of *MaaS Lite* exists at the lower end of the MaaS maturity curve shown in Fig 2 below.

A mobility scheme depends on the availability and performance of various transport assets, such as buses, trains and interchange points. A scheme may also include walking, cycling, private cars and taxis, to the extent that the modal split in general favours shared transport rather than personally-owned transport. As one of the original UbiGo pilot users pointed out: "*It's not about being a bus user or a pedestrian … it's that you're everything… and having reasonable proportions of each [mode] and to be able to see when I need one and when I need the other*" [6]. This is also reflected in the recently introduced city-wide MaaS scheme in Berlin known as *Jelbi,* branded as '*Eine Für Alle*' (lit. One for All).

Although not the subject of this paper, this multi-modal, contingent view of MaaS is also consistent with aims stated by some city authorities to accommodate the benefits of autonomous vehicles by setting expectations for transport policy framework development that does not diminish the mode share of activity mobility [12]. In this context, the authors propose that the role of autonomy in a MaaS scenario should be to reduce the operating costs and improve the efficiency of shared

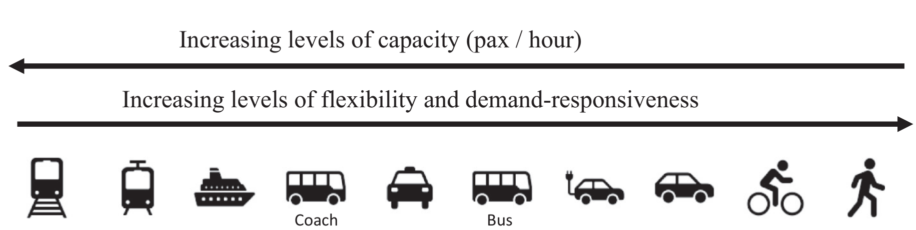

Fig. 1. Mapping of modes against flexibility of route, travel time and degree of demand-responsiveness.

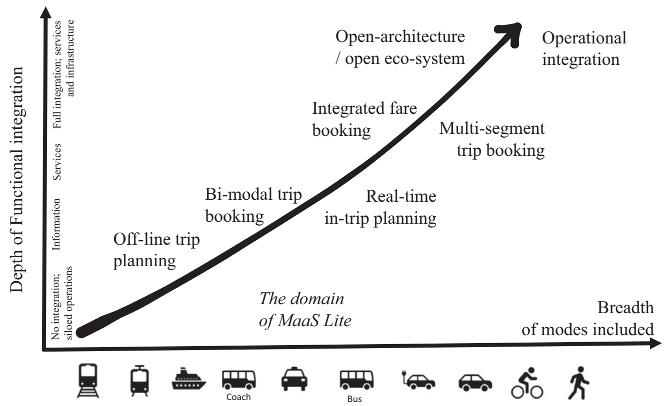

Fig. 2. MaaS Maturity curve and the domain of MaaS Lite.

transport rather than to replicate the convenience of taxis or private cars, or to reduce the mode share of walking and cycling.

Invariably, the efficiency of transport depends on the availability of physical infrastructure, whether it is for the exclusive use of a mode such as rail, subway, light rail/tram schemes; or access to roads and pavements by vehicles and pedestrians. If the infrastructure is not available due to its destruction, poor maintenance or other unplanned events, then the quality of transport that rely upon it will diminish and the quality of any mobility services that depend upon transport operations will also suffer. Depending on the level of physical redundancy between infrastructure provided for different modes, MaaS can improve the resilience of a transport network by enabling a much more fluid relationship between transport operators and users, enabling alternative route and mode choices to be made efficiently in the event of incidents. The Traffic and Incident Management (TIM) System in Hong Kong is one of many international examples that aims to achieve this [13]. Nevertheless, since mobility relies on high quality infrastructure then advanced mobility concepts such as MaaS is no different.

2.1. The context of MaaS lite

At the risk of over-simplification, there are several common themes in any MaaS implementation, namely the policy aims for transport service integration, the level of importance associated with user-centric services delivery, level of recognition of all modes, and the priority given to supporting users at every stage of their journey from door-to-door and not only from bus stop to another. For the latter, this could include pre-trip planning, through to in-trip advisory and then, when the trip has finished, learning to do better next time.

Generally, a MaaS scheme may be categorised by:

(a) the split of ownership of the assets (i.e. data, vehicles and infrastructure) between public and private entities; and
(b) the extent and level of integration of the modes, ranging from single mode, through modes that are 'coordinated' by the governing authority to modes that are integrated at every level – such as the use of harmonised branding, ticketing, data sharing as needed, and customer-centric services alignment.

We have already asserted that a high level of importance should be attached to user requirements, including the development of a public domain standardised interface to a conceptual Mobility Operator. Arguably, a MaaS scheme can be delivered without any additional user interface at all. Knowing how, where and when a user commences a trip applies to all services whether or not they depend on users having a smart phone or not.

As a notable case, a simple monomodal, yet highly scaleable scheme is highlighted in Mumbai (India). In this example, a demand-responsive shared taxi scheme is demonstrated: at several ranks in Mumbai, each taxi advertises a general destination and a fixed price, and the taxi leaves when full [14]. This shows how resource sharing can benefit many stakeholders and improve mode efficiency, in this case by increasing taxi utilisation by dynamically aligning users with similar destinations. What does this non-digital example say about demand responsive services in general and how they should be defined?

Clearly, inclusivity should depend upon having an efficient interface (digital or not). As a hypothetical example, the simple act of boarding a bus to commence a multi-modal trip should be all that is required of the user to trigger the underlying processes that would enable a party acting as a Mobility Operator to deliver an affordable, connected and efficient trip for the user. However, not all cities would have the necessary pre-requisites to enable MaaS at the most advanced end of the maturity curve, such as accepted standards for data sharing, a common means of payment, willingness to share data and trust between the public and private sector roles.

This paper argues that scheme design simplicity, accessibility, convenience and low risk of trial - as perceived by users - should be the focus of any MaaS scheme. The converse is not appealing for users at all, namely requiring users to navigate through multiple interfaces, disparate data sets (whether real-time or not) and diverse means of payment – all of which mitigates against a MaaS scheme that could match the convenience of private means of transport thereby giving users the justification to migrate. Implementing an interoperable ticketing scheme to improve convenience of payments is often an important step, and the early implementation of the locally interoperable *Octopus* stored value card in Hong Kong, elaborated further below, was no doubt a contributor to Hong Kong's global leadership in public transport mode share.

For the purposes of this paper, *MaaS Lite* is focused on delivering the most common trips that comprise a limited number of means of transport, the use of demand responsive services where possible, and a fare payment mechanism that is readily accessible and aligned with mode options. To the extent that it can fill the gaps in existing transport provision, *MaaS Lite* overlaps with many of the characteristics of MoD. For example, in rural areas where connectivity options are non-existent, *MaaS Lite* and MOD would be similar if not for the potential for *MaaS Lite* to have the potential to connect operationally with other mobility services. For example, a ferry that arrives late could cause an interconnecting bus service to wait, thereby prioritising incoming users above the need for bus departure punctuality. Also, a user that provides permission for his/her ETA to be disclosed by a rail operator for a pre-booked bi-modal trip, could enable a interconnecting taxi service to be alerted as needed, reducing taxi driver waiting time whilst avoiding the need for the user to manage the train-to-taxi transfer. Offering personalised services to every user underpins MaaS in general.

MaaS Lite also emphasises that one of the most important gaps in transport provision is the First Mile Last Mile (FMLM) segment which underscores the need for *MaaS Lite* to enable both FMLM and integration with public transport. Without this, if a user perceives a gap (whether true or not), such as a lack of public transport at the destination, then this could influence the modal choice for the whole journey: "*[and] a result, they just pick a car up from their home or their office or wherever and drive the entire trip*" [15]. This suggests that focusing on user needs, in this case providing confidence that 'whole trip' needs would be met, can help prioritise shared transport above private transport, thereby demonstrating that service improvement could partially substitute for investment in road infrastructure. However, assuming a pedestrian-oriented walking environment results "*… in a 70 % increase in walking distance, the spatial size of a (theoretical) radial catchment area around public transport stops would triple in size*" [16], then investments in walkability as a FMLM option would be consistent with the aim of the 'whole trip' approach requirement presented above.

2.2. Characteristics and role architectures

The characteristics of MaaS, *MaaS Lite* and MOD are highlighted in Table 1 below, presented to highlight the intended conceptual differences between MaaS and *MaaS Lite* rather than as an inviolable definition of any.

The user-centric definition of MaaS presented above neither implies a centralised nor decentralised structure. Similarly, it does not mean that a new organisation would be needed to act as a Mobility Operator, particularly as there may be concerns that this new organisation could add to the cost of delivering a trip or reduce the profitability of incumbents. MaaS and *MaaS Lite* both reflect a multi-modal approach which means that a user is offered trip options ranging from a single point-to-point mode to trips that comprise segments that are operationally connected. Since most trips comprise only 1 or 2 modes then an efficient interchange between one mode (or operator) and the next requires some data sharing. The simplest role architecture for *MaaS Lite* is based on operational integration between one Transport Service Provider (TSP) and another, based on data structures suitable for peer-to-peer data sharing (Fig. 3).

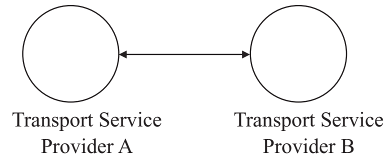

Fig. 3. Role architecture: peer-to-peer data sharing model between TSPs.

If *MaaS Lite* was employed as a first step towards a centralised MaaS architecture (Fig. 4), then one of the parties could assume the role of a Mobility Operator (Fig 4) which would specify a data exchange standards from the many that are publicly available, ranging from XML for self-descriptive messages; GTFS for transportation schedules, dynamic data of vehicles and associated geographic information elements; NeTEx that supports upstream data value chain members and traveller information system; and more recently the '*Public Transport – Reference Data Model*' (Transmodel v6.0) European Standard, EN 12896 for timetable, public transport real time data and fare data.

In the simplest example, data exchanges that are triggered on a 'need to know' basis could be used to provide minimal information from one TSP to another on the trip requirements of a user that needs to transition to a new trip segment. Given this adhoc peer-to-peer *use case*, an agreement for settlement and a service level guarantee from the 'acquiring' TSP would also be needed – but for a centralised account, confirmation of service purchase (or delivery) would be needed from a TPS to the account management authority.

The next stage of transition in the evolution is to include an additional TSP as shown in Fig 5 below, but only if the business case allows it.

2.3. The many flavours of MaaS

Operational integration between operators or modes, would be underpinned by an efficient transport interchange (geographic integration) and ideally, sufficient service flexibility to minimise inter-segment waiting times and the convenience and quality of the interchange perceived by users. Simple measures of performance (such as adherence to a published timetable) may not adequately reflect the quality of service as perceived by a user may not be sufficient, particularly if this neglects the well-being of the user and his/her security.

Furthermore, service flexibility may be defined by the ability to vary the route, arrival/departure times or capacity – or all of these. However, each of these is likely to be subject to local regulatory constraints and therefore some de-regulation may be necessary. Furthermore, in the worst case, mistrust amongst TSPs may be observed as continued investments within their respective 'mode silos' rather than investment in inter-silo activity which as we have argued above, would enhance user benefits for multi-modal trips, permit increased service differentiation and enable cost reduction through improved service efficiency. Conflict analysis shows alignment between TSP's in a growing market but increasingly defensive postures in a mature market. Similarly, private sector platforms that have emerged from a private sector TSP are likely to favour improving the utilisation of the TSP's assets over 3rd party assets.

The variation between cities in regulation, TSP profitability, competitive environment, user demographic, route lengths and spatio-temporal demand profiles suggest that MaaS would not look the same in every location. Whilst mobile phone-based trip planning applications can be rapidly scaled amongst cities of different sizes and locations internationally, we hypothesise that the more complex array of institutional arrangement required for a most advanced forms of MaaS cannot be easily scaled and that the principles of MaaS invariably require localisation. The principles of *MaaS Lite* recognises this and delivers many of the benefits of MaaS by recognising that most users' trips are not complex at all.

As a second example, the lack of integration of a new service within the transport hierarchy could have been addressed by enhancing an existing operation instead. The increased use of data for service integration, the potential to collect end-to-end trip data in a standards-compliant format, the use of common ticketing (or single ticketing interface) could also allow for 'service discovery' i.e. using anonymised geo-coded data to identify areas that have lower levels of accessibility to public transport. In turn this richer data set could provide sufficient support to validate the business case on gap-filling services, thereby benefitting users and proximate TSPs.

The scope of this paper does not allow for an on-street validation of an incremental approach to MaaS via *MaaS Lite* but as a first step we consider case studies from two very different cities: Hong Kong SAR (China) and Brisbane (Australia) to assess the potential for MaaS or *MaaS Lite* in each.

2.4. Case study 1: Hong Kong

Hong Kong has one of the highest population densities in the world (6700 people per square kilometre), which would be higher considering that less than 25% of the land area is urban or built up areas. Over 12 million trips per day are made through different public transport services.

Table 1
Prerequisites.

Characteristic	MaaS	*MaaS Lite*	MOD
Means of payment	Common to all modes	Offers a common mode and others	Choice between a common mode and others
Payment mechanism	Subscription and trip-based	Subscription and trip-based	Trip-based
Geographic connectivity	Yes	Yes	Yes
Data sharing	Yes	As needed, for each trip	Does not rely on this
Operational connectivity	Yes	Yes	No
Mode focus	Multimodal	Few modes	Monomodal
Users	Personal	Personal	Personal & goods
Customisation	Extensive, across all modes and times	Limited, to reflect the most common trips and transitions	Largely commodified

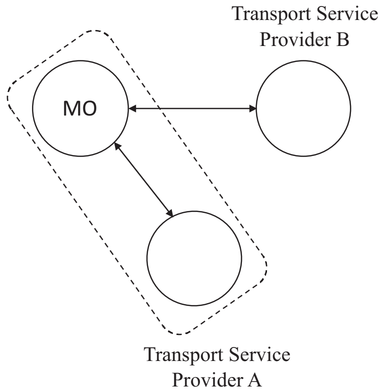

Fig. 4. Role architecture: data sharing model between TSPs, stage 2.

Public transport accounts for 90% of passenger trips per day, ranked the highest globally. Transport Department (TD) regulates most aspects of transport and manages traffic flow, but it does not operate any service, but instead depends on for-profit operators to deliver public services for road, cross-boundary and inland waterways.

Rail is the backbone of public transport carrying over 43% of passengers, followed by franchised buses (32%), minibuses (14%) and taxis (7%). Hong Kong introduced Octopus, an interoperable contactless stored value card to pay for transport services and topped up automatically or at retail outlets. Octopus was introduced in 1997 as Hong Kong's first licensed Stored Value facility (SVF) and following the formalising of the SVF scheme in 2016, there have been a further 17 SVF licensees, some of which provide highly scalable app-based payment services for transport. The currently operating Hong Kong Transport Fare Subsidy Scheme gives users a 25 % discount on their public transport costs beyond an initial HK$400, subject to a maximum of $300 subsidy per month.

There are 787,000 registered vehicles, which reflects an increase of 2.4% compared with July 2018 [17]. Vehicle ownership in Hong Kong is low (0.3 vehicles/household) because of the high cost of owning a vehicle. There is also no regulatory support for ride sharing schemes such as DiDi Chuxing or Uber that uses self-selected drivers although government proposes a limited reform by increasing the current population of franchised taxi by increasing the population by 450-600 (about 3.3%) as 'premium taxis' to broaden user choice [18]. Potentially, the resistance to reform amongst established incumbents, otherwise known as the 'Olson Problem' [19] would be mitigated by providing for a regulatory domain that preserves any pre-reform initiative by creating another domain alongside it [20] Existing licensed taxi operators have the option to join one (or frequently more) ride sharing platforms such as HK Taxi that commands about 70% of the ride share market. As a potential FMLM option, there is no enabling regulation for micro-mobility devices although an ongoing Government-led study [21] will consider this.

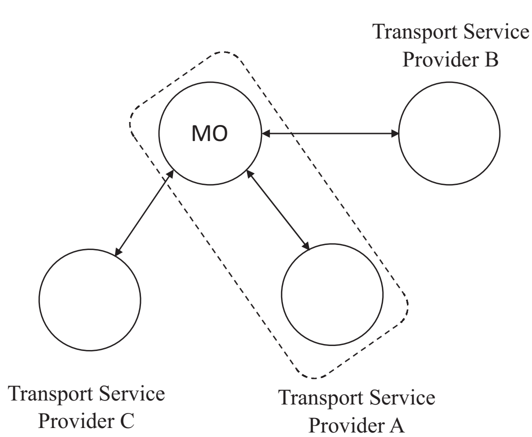

Fig. 5. Role architecture: peer-to-peer data sharing model, stage 3.

The Hong Kong SAR government's transport policy aims to maintain rail as the backbone of territory-wide mobility options. Other services are either regarded as feeding MTR or being complementary to it in areas not served by rail. Real time bus information of each bus operator is available on each bus company's mobile app, but real-time data is not currently shared amongst transport operators. Overall, it may be concluded that Hong Kong's transport system is not integrated but 'coordinated'. Given the high PT mode share, low vehicle ownership and no incentives for data sharing, the barriers to implement MaaS in Hong Kong could be high. The pointed questions are what shape should MaaS adopt in Hong Kong and, if MaaS could improve individual's mobility, who would be the target market? Would MaaS be marketed to habit-bound commuters, offered as an employee scheme, a residents' scheme or be focused on tourists?

The majority of mechanised trips (84%) made daily involved only a single mechanised mode trip leg [22]. The remaining 14% and 2% mechanised trips involved 2 and more than 2 mechanised legs, respectively. A *MaaS Lite* service that provides real time information for 2 modes such as MTR (railway) and a franchised bus in a single mobile app with a single mobile payment option could improve a large proportion of the 16% multi modal trips. This is because the combined patronage of MTR and the largest franchised bus operator, KMB, is about 60% of all trips on public transport. *MaaS Lite* would be easier to implement than a full MaaS scheme since it could be limited to peer-to-peer agreements, and it could improve the users' mobility and accessibility to public transport. Limited regulatory support, particularly if a service requires some variation in route, capacity or timing, would be necessary.

MaaS Lite could be applied in areas where demand is geographically diffuse (e.g. linking sub-urban shuttles to MTR in Hong Kong) and would be applied during peak, off-peak or where sufficient demand permits to emphasise the spatial and temporal application of it. Effectively *MaaS Lite* is applicable to an area, corridor or route. Given sufficient integration between FMLM modes and MTR, the authors hypothesise that this could reduce end-to-end private vehicle trips as a contributor to reduced traffic, reduced congestion and reduced journey time variability. Lesson learned from microtransit schemes articulated above, suggests that the pre-requisite for viability of an on-demand FMLM scheme is operational integration which could be, as a minimum, efficient mini transport interchanges. The convenience afforded by future premium taxi-based ride sharing service would not only increase the mobility of citizens but could increase the number of end-to-end trips and so it is arguable as to whether this mode should be part of MaaS Lite or through the inevitable differential pricing be considered complementary to it. Regardless, although the Hong Kong variant of *MaaS Lite*, emphasised here as *MaaS Lite Hong Kong* would benefit all existing modes, both would better match capacity with demand.

2.5. Case study 2: Brisbane

Brisbane is the third largest city in Australia with a population of 2.4 million people in Greater Brisbane area and the population density is about 145 people/km^2 about 2% that of Hong Kong. Brisbane has a vehicle ownership of approximately 1.5 vehicle/household and over 50% of Greater Brisbane's households have 2 or more cars [23]. Four out of five trips in Greater Brisbane are made using a private vehicle and only 10% on the trips are made using public transport [24]. Brisbane's high private ownership and usage is aligned with one of MaaS objectives to reduce vehicle ownership. There is good public transport coverage in Zones 1 and 2 but limited coverage in the outlying areas since the population density in such areas is low. Any transport policy that encourages reduced ownership of second or third vehicles, especially those living in Zone 1 and 2, would require providing easier access to public transport and local activity centres such as shopping centres. Increasing the size of the catchment areas for public transport nodes, through investment in pedestrian-friendly infrastructure, as described above could be part of the solution and would be supportive of MaaS.

Similar to Hong Kong's Octopus card, Brisbane has the *go card* used for all public transport modes and to access *CityCycle* (a bike sharing scheme). In addition, real time public transport information and multi modal trip planning are available on Brisbane's Translink App. The pointed questions are how could MaaS reduce Brisbane's high dependency on private vehicles; how can MaaS meet Brisbane users' travel needs better than the decentralised travel options available now; and can a mobility operator value add to the existing travel services and be sufficiently profitable to operate in Brisbane?

It is clear that real time public transport information, multi-mode PT trip planner and electronic payment systems alone are not going to get people in Brisbane to start using public transport. Easier access to and from public transport stops and stations aims to get people to leave their cars at home or not to own the second or third car. In the public transport Zone 1 and 2, a Brisbane variant which we shall call *MaaS Lite Brisbane*, that combines ride sharing or demand responsive transport with public transport and mobile payment, would improve accessibility and mobility of users. Interoperable payment based on a mobile app-enabled, single user identity, multi-mode, account-based system, is preferable to existing hardware-based card system because it is easier to integrate “new” modes, easier to scale (e.g. does not depend on users acquiring any hardware device, whilst distribution and updates are managed Over The Air), permits pricing across modes and passenger data collected in the back office can be analysed to provide better transport options. By comparison, the rather more limited concept of an 'integrated public transport ticketing and information' system does not reflect the user-centric management framework and an aggregated mobility management that is defined by the principles of MaaS described here.

MaaS Lite Brisbane would target second vehicle buyer/owners and could be priced as a subscription that is similar to or slightly higher than the cost of servicing a loan for a car since overall, it would still be less expensive than owning a vehicle (e.g. depreciation, loan payment, maintenance, registration, insurance, parking, etc.) and it would have reduced externalities (e.g. contribution to harmful emissions and congestion). Cars are parked for 5% of the time [25] [26], far lower than the minimum utilisation that would be considered viable by any public transport operator, and this is consistent with either (a) users understating the true costs of private car ownership, (b) convenience being of primary concern to many car owners or (c) both. Therefore, as stated above, any goal to reduce car use through the implementation of *MaaS Lite Brisbane* would need to consider the cost to the user, its convenience and integration with downstream modes. Signalling the true cost of private car ownership would also need to be considered, since it has been shown that users have a tendency to understate their costs [27]. *Maas Lite Brisbane* could in fact be good for the user's hip pocket.

Like Hong Kong, Brisbane has an integrated payment system, known as *GoCard* for all PT modes. Similar to Hong Kong public transport interchange discount, the pricing policy incentivised multi-modal trips. For example, public transport trips made within 2 h of the last trip are considered as a transfer. Fares are calculated based on the number of zones travelled, whereas in Hong Kong for the MTR are based on an access fee, a cross-harbour levy and a distance-based charge.

The operator is *TransLink*, a division of the Department of Transport and Main Roads and operates buses, regulates all other mods and promotes active mobility. Translink has offers a mobile application that shows real time bus, ferry and train information. Brisbane's investment in its transport system has been significant but despite this, the mode share of public transport has declined from 20% in 1976 to 13.5% in 2016 [28] and a new approach is needed.

The questions are: who would benefit from MaaS in Brisbane? Could MaaS offer an alternative to regular commuting by car, could a MaaS ‘bundle’ include a FMLM provision? Would car sharing or ride sharing services work? Initial experience suggests that car sharing scheme that originate and terminate a designated car parks at local convenience stores could reduce the need for a second vehicle. A typical household in suburban Australia without a second car would need to have access to car sharing, ride sharing, carpooling, scooter sharing and bicycle sharing services on top of public transport. The UK's RAC Foundation support this view. An analysis of the National Travel Survey [NTS] [29] “*underscores the massive savings that could be realized if cars were used more efficiently via car-sharing or on-demand services like taxis or [other commercial operators]*” [25].

3. Summary and conclusions

The authors posed the question whether MaaS would look the same for all types of economic areas? Hong Kong and Brisbane reflect different regulatory regimes, population densities and levels of private car ownership. Both can reasonably claim excellent provision of road infrastructure, whereas Hong Kong has incomparably high level of public transport usage. Conversely, urban planning in Brisbane has historically been car-centric, consistent with low levels of public transport mode share. Both have high levels of mobile phone usage and a common ticketing scheme.

This paper describes locally applicable flavours of MaaS, termed *MaaS Lite Hong Kong* and *MaaS Lite Brisbane* to address shortcomings in both areas, including poor provision of FMLM. The focus of *MaaS Lite* on specific geographic areas, modes and potentially (time of day) permits a simpler organisational arrangement and does not depend upon the introduction of a Mobility Operator as a new player. The authors hypothesise that *Maas Lite* permits the business case for MaaS to be as well-defined as the focused services that are offered although we emphasise that, as a minimum, effective integration that improves the convenience of public transport is a necessary pre-requisite.

The trajectory of evolution could be to add modes, offer more sophisticated pricing policies, pre-booking and add a subscription-based monthly payment option, as seen in the precedence-setting pilot MaaS scheme in Gothenburg in 2012 and from May 2019 in Stockholm, both orchestrated by a publicly-linked Mobility Operator. By comparison, Berlin's *Jelbi*-branded MaaS scheme launched by *Berliner Verkehrsbetriebe* (BVG) in October 2019 [31] covers 12 modes with one app, each priced separately and accessed with a single user identity, offering bikes, e-kick scooters, e-scooters, shuttles, car-sharing, and taxis with a single payment for each connected trip. One app, one payment, no Mobility Operator, no bundling, no subscription and transport operators pay a service fee but no commission.

Overall, MaaS is not a ‘one size fits all’ solution for all regions but the benefits of the highly targeted *MaaS Lite* could realise earlier public benefits and could be regarded as a valuable first step in a multi-phased ‘services road map’ that evolves towards the implementation of multi-modal, region-wide operationally integrated MaaS. Maximum benefits would be realised through investment in two categories of infrastructure: digital infrastructure to improve the accessibility and operation of the services themselves by means of proven mobile payment mechanisms, use of mobile user identities, app-based interfaces and needs-based trip-centric data sharing, and pedestrian infrastructure to increase the catchment area to public transport.

For some regions, *MaaS Lite* may be seen as the end point since it supports a ‘whole trip’ approach to trip management, enables user personalisation, amongst a limited local relevant mode choice, ensures a low perceived risk of entry for users and it enables an earlier time-to-market than a more complex, large area multi-modal MaaS scheme - which *MaaS Lite* can ultimately enable.

References

[1] Institution of Engineering & Technology, Could Mobility as a Service Solve Our Transport Problems? February 2019.
[2] User-Centered Public Transport: On-Demand Bus Service Kutsuplus2015.
[3] S. Heikkilä, Mobility as a Service – A Proposal for Action for the Public Administration, Alto University, April 2014 Thesis submitted for examination for the degree of Master of Science in Technology.
[4] O. Sulopuisto, Why Helsinki's On-Demand Bus Service Failed, 2016. https://www.citylab.com/transportation/2016/03/helsinki-on-demand-bus-service-kutsuplus/472545/.
[5] J. Sochor, Benefits of Mobility as a Service: Evidence from the UbiGo MaaS pilot in Gothenburg, Sweden, 23rd Intelligent Transport System World Congress. , Melbourne Convention and Exhibition Centre, Melbourne, 2016 (11-14 October 2016).
[6] US Department of Transport, Mobility on Demand (MOD), "Transform the Way Society Moves", MOD Fact Sheet #1: Overview2019. https://www.its.dot.gov/factsheets/pdf/MobilityonDemand.pdf.
[7] BBC, Slide Bristol Shared-Ride Minibus Scheme to Close, 27 November 2018.
[8] L. Bliss, Bridj is Dead, But Microtransit Isn't, CityLab, May 2017.
[9] A. Schmitt, The Story of "Micro Transit" Is Consistent, Dismal Failure, Streetsblog USA, 2018.
[10] M. Enoch, et al., Why do demand responsive transport systems fail? Transportation Research Board 85th Annual Meeting, 22–26 January 2006 , Washington DC.
[12] Transport for London, Connected and Autonomous Vehicles, 2019.
[13] PIARC, Case Study: Traffic and Incident Management (Hong Kong), 2015.
[14] S. Sen, 'Happy commuters share rides, Save cash', Times of India, 28, September 2010.
[15] G. Miskelly, K. Calderwood, How experiments in shared transport are slashing Sydneysiders' commutes, ABC News (6 October 2019).
[16] H. Knoflacher, Zur Harmonie von Stadt und Verkehr: Freiheit vom Zwang zum Autofahren, 2nd ed. Böhlau, Wien, 1996.
[17] Hong Kong Transport Department, Travel Characteristics Survey 2011 Final Report, 2011.
[18] Introduction of Franchised Taxi Service Proposed. , Transport & Housing Bureau of the Hong Kong SAR Government, 17 April 2019.
[19] Mancur Olson, The Logic of Collective Action: Public Goods and the Theory of Groups, Harvard Economic Studies, 1965.
[20] Sharing economy and regulatory strategies towards legal change, Eur. J. Risk Reg. 7 (4) (December 2016) 717–727.
[21] LCQ13: Electric Mobility Devices30 January 2019.
[22] Hong Kong Transport Department, Travel Characteristics Survey 2011 Final Report, February 2014.
[23] Australian Bureau of Statistics, Census of Population and Housing 2011 and 2016, 2019, Compiled and presented by .id, the population experts https://profile.id.com.au/australia/car-ownership?WebID=270.
[24] Queensland Department of Transport and Main Roads, How Queensland Travels: A Decade of Household Travel Surveys in Queensland, 2017.
[25] A. Schmitt, It's True: The Typical Car Is Parked 95 Percent of the Time, Streetsblog USA, 10 March 2016.
[26] Economist, Aparkalypse now, The Perilous Politics of Parking6 April 2017.
[27] KPMG, Mobility 2030: Transforming the Mobility LandscapeSeptember 2019.
[28] Trends in Journey to Work Mode Shares in Australian Cities to 20162nd ed., 1 December 2017 ChartingTransport.com.
[29] Spaced Out: Perspectives on Parking Policy. , RAC Foundation, 17 July 2012.
[31] Jelbi, Eine Für Alle, accessed at https://www.jelbi.de 2019 on 6 October 2019.