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The importance of user perspective in the evolution of MaaS

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ABSTRACT

The rapid emergence of Mobility as a Service (MaaS) into the transport sector's lexicon has brought with it an air of expectation that suggests a future mobility *revolution*. This paper focusses on the user perspective and offers a deepening of socio-technical thinking about MaaS and its prospects. It first provides an examination of what is understood to date about MaaS in what is a new but rapidly evolving body of literature. This highlights the concept of MaaS as a 'mobility system beyond the private car' and the new centrality of a 'mobility intermediary' layer in that system. The paper then focuses and elaborates upon its contention that MaaS is neither new nor revolutionary but is rather an *evolutionary* continuation in terms of transport integration. Emerging from an era of unimodal travel information systems becoming multimodal and then integrated multimodal information services, MaaS is now about adding seamless booking, payment and ticketing to the integration offer. The paper puts forward a 'Levels of MaaS Integration (LMI) taxonomy' analogous to the level 0–5 SAE taxonomy for automation of road vehicles. This taxonomy, designed around the user perspective (including cognitive user effort), concerns operational, informational and transactional integration that it is suggested reflect a hierarchy of user need. From a synthesis of insights from the 'pre-MaaS' literature concerning choice making for travel and the role of information, a MaaS behavioural schema is provided to illustrate potential consideration and adoption of MaaS from the user perspective. In concluding, the paper considers what a user perspective reveals for the future prospects of MaaS and in particular for the mobility intermediaries.

1. Introduction

Mobility as a Service (MaaS) by name is in its infancy. It is a "nascent phenomenon" (Smith et al., 2018). In her 2014 Masters thesis, Heikkilä describes it as "a system, in which a comprehensive range of mobility services are provided to customers by mobility operators" where a mobility operator is "a company, which buys mobility services from service producers, combines them as a service supply and provides the services to customers" (Heikkilä, 2014: 8). One of her instructors, Sampo Hietanen from ITS Finland, went on to found MaaS Global, billed as "the world's first ever mobility operator"[1]. In this paper we use the term 'mobility intermediary' rather than mobility operator to ensure a clear distinction from the operators of transport services.

There is a groundswell of enthusiasm surrounding the core proposition of MaaS, namely to provide the user with access to the

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[1] https://maas.global/company/.

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collective offering of a choice of different transport options through a single information, booking and payment service. MaaS trials of different scale and ambition are happening across the world. Insights into the barriers and enablers to success are emerging, but the existing literature explicitly addressing MaaS is limited.

However, it would be a mistake to presume that MaaS is an entirely novel concept. There are some significant new factors at play, but the development of information services to inform, support and influence travel behaviour in the planning and execution of journeys across modes has a long history. Indeed, the goal of achieving a more integrated transport system is decades old (and the 'last mile' link remains a key challenge for a truly integrated door-to-door approach).

This paper focuses particularly upon the user perspective regarding MaaS. Success of MaaS is ultimately dependent upon a shift in behaviour away from reliance upon *private* car ownership (Mulley, 2017) towards using other modes (in combination). Further still it is dependent upon users valuing the mobility intermediary proposition as a medium through which to access and pay for mobility services, as opposed to accessing and paying for such services more directly for themselves.

Section 2 provides an examination of what is understood about MaaS to date, in what is a new but rapidly evolving body of literature. Section 3 focuses and elaborates upon the contention that MaaS is neither new or revolutionary but is rather an *evolutionary* continuation of transport integration. A taxonomy of MaaS is put forward analogous to that for levels of vehicle automation, but based on the user perspective. Section 4 moves to provide a synthesis of insights from the 'pre-MaaS' literature concerning choice making for travel and the role of information. It includes a behavioural schema illustrating the consideration and adoption of any new MaaS offer from a user perspective. The paper's conclusions are set out in Section 5.

2. The prospect of MaaS

In this section we develop an understanding of the MaaS proposition, the opportunity it represents for a move from car ownership to mobility access - allied to new underlying dynamics in society's travel behaviour - and some of the challenges faced. We outline the constituent layers of the mobility system beyond the private car and thereby begin developing our user perspective on MaaS as well as considering evidence to date of MaaS trial participants' behavioural responses.

2.1. What is MaaS?

From a user perspective, MaaS is portrayed as, or aspires towards, offering an appealing alternative to owning and using a private car. It is characterised by: door-to-door convenience (Kamargianni et al., 2016); seamless, integrated, multi-modal travel (Li and Voege, 2017); and ease of payment/billing (Jittrapirom et al., 2017a). MaaS is enabled in technological terms by the connectivity and functionality offered by the mobile internet and related devices, notably smartphones (Hensher, 2017; Li and Voege, 2017). Jittrapirom et al. (2017a, 2018b: Table 1) list nine core characteristics of MaaS: integration of transport modes; tariff option; one platform; multiple actors; use of technologies; demand orientation (including demand responsive services such as taxi); registration requirement; personalisation; and customisation. The MaaS vision is "to see the whole transport sector as a co-operative, interconnected eco-system, providing services reflecting the needs of customers" (Hietanen, 2014: 27)[2].

For MaaS to exist, the mobility intermediary is reliant upon bringing together mobility service providers (i.e. the organisations providing the means of travel across the different available modes) and securing their co-operation in relation to: (i) access to their services and related data and information; and (ii) agreement on appropriate pricing of services and sharing of revenues (where the mobility intermediary intends to provide a booking and payment service). Giesecke et al. (2016) point towards such brokerage and the prospect that by representing (potentially) a large number of 'clients', the mobility intermediary can *in theory* negotiate more favourable pricing on their behalf with the mobility service providers. Questions remain over the financial viability and profitability of the MaaS business model in this regard (TfL, 2018). In practice, the challenge appears to relate to point (i) above as a precursor to point (ii) – evidence submitted to the UK Parliament's Transport Committee Inquiry into MaaS[3] highlights: data as the key enabler of (or barrier to) "the integration of the operations and business models" (Ito World, 2018: 1) with issues of availability and consistency (Viaqqio, 2017); the reluctance of mobility service providers to engage (DfT, 2017), in part because they are reluctant to cede 'ownership' of their customer (Viaqqio, 2017); and, in turn, the lack of access to mobility service providers' booking and ticketing systems with no obligation (in the UK – unlike that now introduced in Finland) for mobility service providers to provide third party access to their APIs[4] (MaaS Global, 2017; Uber, 2017).

The MaaS business model has been inspired by that of the mobile phone market (Hietanen, 2014; Li and Voege, 2017) in terms of the distinction between 'pay as you go' and subscription to a package with capped or unlimited usage of services. MaaS Global's Whim service (accessible through an app) is an example of this and is described here to illustrate the sort of MaaS offer a (prospective) user can be faced with. Having first been launched in Helsinki, Whim has subsequently been introduced to the West Midlands in the UK[5] with a trial phase (seeking 500 users) that started in April 2018. This has been initially covering public transport (buses, trams and trains in the West Midlands), taxi and hire car - with bike share 'coming soon'. The service offers three options: 'pay as you go' (no

[2] Such a vision relies, amongst other things, upon supply-side development of the transport system itself in terms of infrastructure and vehicles.

[3] https://www.parliament.uk/business/committees/committees-a-z/commons-select/transport-committee/inquiries/parliament-2017/mobility-as-a-service-17-19/.

[4] Application Programming Interfaces.

[5] https://whimapp.com/uk/.

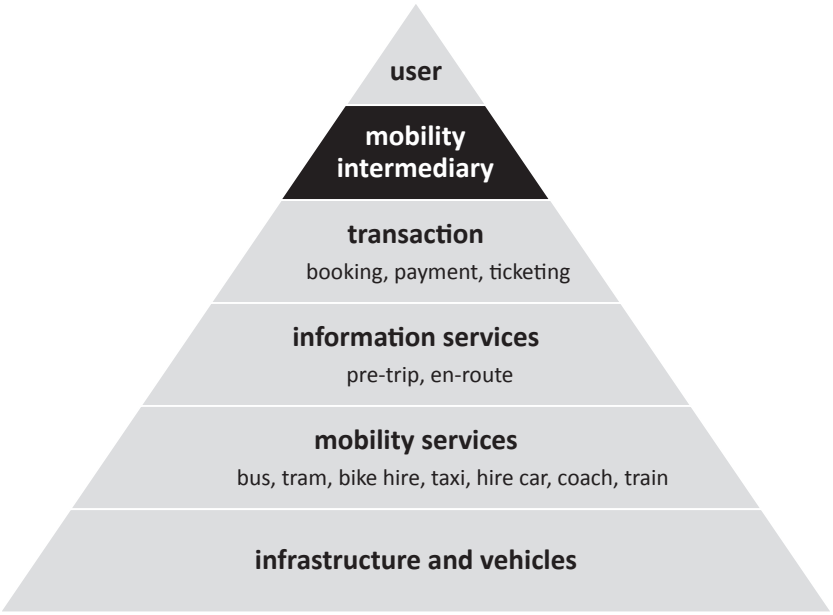

Fig. 1. The mobility system beyond the private car.

monthly subscription); 'Whim Everyday' (£99 introductory monthly subscription with price capping); and 'Whim Unlimited' (£349 introductory per month payment). Public transport use is unlimited for 'Whim Everyday' but unlimited access to taxi (journeys of up to 3 miles after which standard fares apply) and car hire (no indication of fuel being included) is only included with 'Whim Unlimited'. It can be suggested that 'unlimited' may be misleading with the user required to carefully scrutinise what is on offer. This set of service plans gives an indication of the potential challenge facing users in judging which, if any, of the plans are likely to offer them value for money. Hensher (2017) notes this being an initial challenge for participants in the UbiGo transport broker service trial in Gothenburg, Sweden as participants got to grips with their changed mobility needs as part of the trial, discovering in particular that they overestimated their need for car access as part of the plan purchased (Karlsson et al., 2016).

To help clarify an overview understanding of the MaaS proposition, we offer Fig. 1 as a user-oriented depiction of the mobility system beyond the private car. An *infrastructure and vehicles* layer forms the foundation, providing the physical means to get from origin to destination (as is also applicable to private car use). This forms the basis for the *mobility services* layer whereby such means are made available for consumption by (prospective) users. The *information services* layer is a means through which users can interrogate the availability of mobility services, plan journeys and access support in journey execution. There is then a *transaction* layer involving a need to pay for the mobility to be consumed, with potential prior booking, pre-payment, and related ticketing. The distinct component of MaaS is then the *mobility intermediary* layer. This provides the interface between those layers necessary for journeys to take place and the *user* who undertakes the journeys[6].

The mobility intermediary is supported by the layers below and in turn supports the user by providing convenient 'one-stop-shop' access, through subscription or pay as you go, to those layers. Different organisations occupy the different layers though may exist in more than one layer. The conceptual appeal of introducing the mobility intermediary layer is the (sense of) integration and convenience that this can provide. Integration is key to the user perspective and we return to this in Section 3. In the remainder of Section 2 we now proceed to examine more closely the prospects for MaaS in terms of its potential influence on the mobility system, the mobility options users are faced with and the behavioural consequences.

2.2. From ownership to access

A central proposition of MaaS is to move from a model of private vehicle *ownership* to mobility *access* (Jittrapirom et al., 2017a). Mulley suggests that the cultural shift from ownership to access may be "one of the biggest hurdles for transition to MaaS" (Mulley, 2017: 249) while Hensher (2017) highlights the continuing need for (corporate) ownership of cars somewhere within the mobility system if they are to remain a (prominent) feature of a MaaS ecosystem. Indeed, traditional motor manufacturers have engaged commercially with mobility intermediaries such as Uber and Lyft, recognising the prospect of emerging new business models (Accenture, 2018) that may recast the makeup of their vehicle sales and their position as suppliers to, investors in and/or providers of mobility services (CAR, 2016).

[6] We note that Smith et al. (2018) distinguish between MaaS integrators "that assemble the offerings of several transport service providers" and MaaS operators (mobility intermediaries) "that package and deliver these offerings to end users".

Part of the cultural shift from ownership to access may be in the form of car leasing – which on the one hand constitutes access while on the other provides private use of a vehicle and a sense of (temporary) ownership. The Whim Unlimited offer referred to above, at £349 per month, includes unlimited car hire of a Ford Fiesta (or equivalent vehicle). Meanwhile, at the time of writing, a personal lease deal on a new Ford Fiesta Hatchback for a 24 month contract period with 10,000 yearly mileage (including maintenance) is available at £326 per month after an initial payment of around £1200 (insurance not included). The two are similar in price overall. The former constitutes access, includes other modes and allows cancellation of the subscription at any time. The latter constitutes a sense of car ownership and involves being locked into the personal lease deal. The comparison illustrates the sorts of choices users face.

Car ownership, car leasing and season tickets all bring about a degree of behavioural lock-in due to the sunk cost involved and the appeal of 'spending up front to save later'. Kamargianni et al (2016) (referring to Axhausen et al., 2000) note the influence of such long term decisions on short term behaviour. MaaS would appear to offer, in one respect, the prospect of helping to 'lock out' car ownership through commitment to monthly (or longer) mobility service plans. In another respect it offers the prospect of reduced lock-in because of the ability to change service plans or indeed to change between modes within a given plan (though Pangbourne et al (2018) suggest that loss aversion could lead to people seeking to get value for money from a monthly 'inclusive' MaaS plan, putting an upwards pressure on the mobility system in terms of demand[7]).

With many households owning two or more vehicles in some countries there is the prospect of a *co-existence* of access and ownership. Clark et al (2016a), in considering the process of change in household car ownership, note the concept of a household having a notional car access surplus or deficit when set against the *integer* levels of household car ownership available. Two cars may be more than are really needed by a household while one car may not be sufficient. In such a context, MaaS may act as a substitute for second car ownership. This is reminiscent of a 2004 advertising campaign by Transport for London called 'My other car is a bus'[8]. Smith et al (2018) in their study involving interviews with 19 MaaS actors active in West Sweden observed that the possibility of MaaS leading to a transition from two to one and in turn perhaps one to no cars in a household was raised frequently. Such movement from ownership to access presupposes, aside from its functional value, a diminished emotional attachment to the car in terms of its symbolic value.

Jittrapirom et al. (2017a, 2018b) point to the prospect that MaaS could positively address accessibility and equity as a result of a move from vehicle ownership to mobility access. Yet it seems unclear how this might arise and to what extent, in a context where different MaaS service plans are available and with scope within service plans for significant reliance upon the car (taxi hailing or car hire) for those able to afford this. Indeed Pangbourne et al. (2018) caution that MaaS might ultimately adversely affect equity of access with reliance upon registration and digitalisation for service access and possibilities for erosion of public transport in favour of car use as part of MaaS. Reliance on smartphone access also prevents MaaS offering 'access for all'.

2.3. Anticipation versus reality

Increasingly, across the world, transport authorities and transport planners are seeking to redress the balance from car oriented infrastructure towards supporting more sustainable forms of mobility. This has proved far from easy to deliver. Why then could MaaS be expected to succeed (and indeed to do so in a transformational manner) where prior efforts over years and decades have met with only limited success?

The answer *may* have as much to do with change in contextual circumstances as it does with any underpinning technological enablement. Trends in urbanisation and digitalisation are impacting how we gain access to people, goods, services and opportunities in society (Lyons et al., 2017), and patterns of travel and travel demand are changing - as illuminated by the Commission on Travel Demand in the UK (Marsden et al., 2018). In recent years, for example, city centre traffic in the UK (with examples of Manchester and Bristol given) has been decreasing while motorway traffic has been increasing. There has been a 30 per cent decrease in shopping trips in the last 10 years, coincident with substantial online shopping. Cycling has been increasing while distance travelled per person by car has been falling across all parts of England. Young people are both learning to drive later and making fewer trips by car. Chatterjee at al in their examination of change in young people's travel behaviour note that in the UK, "29% of all 17–20 year olds had a full driving licence in 2014 compared to 48% in 1992/94" (Chatterjee et al., 2018: 2). They also highlight *uncertainty* of income as well as income level as a factor influencing car ownership. This may have an important bearing on the extent of financial lock-in to mobility options people are prepared to entertain (with pay-as-you-go being less onerous). The phenomenon of 'peak car' has been observed in a number of countries with developed economies and mature transport systems where signals of change of the sort above are being observed (Goodwin and Van Dender, 2013).

There is an air of optimism among some commentators regarding MaaS. Its prospects could indeed be promising given the changing landscape outlined above. However, despite the "adrenal rush" surrounding MaaS (Hensher, 2017: 93), it is too early to judge how it will all play out. Pangbourne et al suggest "[t]he dominant rhetoric surrounding MaaS is technologically deterministic and highly optimistic" (Pangbourne et al., 2018: 44). Growing visibility of MaaS, particularly within the transport sector, does not of itself signal a pending mobility revolution. So far only a modest number of pilots and scheme implementations have emerged; "full-scale implementations reaping the alleged public benefits [of MaaS] are lacking" (Smith et al., 2018: 1). For a good overview of MaaS

[7] Perverse incentives have been observed elsewhere concerning behavioural response to pricing. Company car tax systems that have reduced the tax payable if the vehicle is used more have resulted in additional car travel (see Seely, 2002; and Black, 2008).

[8] https://tfl.gov.uk/info-for/media/press-releases/2004/october/my-other-car-is-a-bus–new-advertising-campaign.

examples globally see (Jittrapirom et al., 2017a). While listing a number of other 'partial' examples of MaaS, they identify 12 MaaS schemes they consider to possess most of the features befitting consideration as MaaS. Over half of these have only come into operation since 2014. Two earlier schemes were pilots and one only reached the planning stage.

MaaS can still be considered a niche development. Transition theory (Geels, 2012) reminds us that while niche developments can be the beginning of a fundamental transition, the stability and inertia surrounding the incumbent regime (see also Smith et al., 2018) can be such that these developments remain niche or even disappear. Regime change requires that the status quo of the incumbent regime is disrupted in a number of ways; in relation to MaaS this would include changes to governance, regulation and procurement of transport system supply-side developments as well as changing demand-side developments in terms of the preferences and behaviours of individuals and organisations. Even if niche developments signal longer term change, to quote the late Roy Amara (past president of the Institute for the Future), "we tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run" (Amara's Law). Gartner's Hype Cycle (Linden and Fenn, 2003; Dedehayir and Steinert, 2016) illustrates well how emerging phenomena can be subject to initially inflated expectations before slipping into the 'trough of disillusionment' as the challenging process of innovation and adoption is negotiated with subsequent progress up the 'slope of enlightenment' to the 'plateau of productivity'.

According to Giesecke et al "MaaS has all the attributes of a 'hyped' socio-technical phenomenon: it seems to be a loosely connected patchwork of optimistic political dogma, activists' enthusiasm, anecdotal evidence of successful services and a firm belief of investors in companies such as Uber" (Giesecke et al., 2016: 1; see also Mulley, 2017). Even if, as a niche innovation, it holds the prospect of growing in scale and influence, it is recognised that a diffusion of the innovation will need to take place (Jittrapirom et al., 2017a; and Smith et al., 2018). The rather modest numbers of participants in MaaS schemes to date likely constitute people who are early adopters (Jittrapirom et al., 2017a) and attracted to participating by curiosity (Sochor et al., 2015a) (as well as by the prospect of flexibility and convenience). The nature and strength of their motivations for engagement may well not reflect those of the wider population.

2.4. Behaviour change

There is very limited insight to date in terms of the behavioural impact of MaaS or its future potential. Kamargianni et al. (2016) point to a need for research to examine not only MaaS as a whole but also its component elements and their influence on consumers in terms of enablers or barriers (e.g. the requirement to register and access a software app in order to access MaaS). Giesecke et al. (2016) provide a rare user-centric view on MaaS. They touch upon matters of convenience that the private car can address and which MaaS would face in terms of travel behaviour, such as: travelling with luggage or shopping; collecting others; and travelling to hard to reach places[9]. An early example of examining user profiles and behaviour in a MaaS trial has been UbiGo and its 190 + participants (Sochor et al., 2015a). Four participant groups were considered: 'car shedders'; 'car keepers'; 'already car sharing'; and 'car accessors'. Results revealed differences across the groups stemming from their behavioural context prior to joining the trial. MaaS Global, in its submission of evidence to the UK Parliament's Transport Committee made reference to survey results from its Whim 'beta customers' in Helsinki in 2016. It indicates that on average survey respondents "reduced personal car use by 50%" and "increased public transport use by over 45%". Participant selection is not explained. Regarding the sample size it is simply stated that "the survey had a small sample size" (MaaS Global, 2017: 2). A more recent pilot is that of the service NaviGoGo[10] involving 98 participating 16–25 year olds in Scotland. While providing access to multiple modes in a single hub, this did not include bus travel in the booking and payment functionality. Of the 480 journeys *booked and paid for* through participants' Navigogo accounts, the following shares across available modes resulted: single occupancy taxi – 58%; multiple occupancy taxi – 19%; train – 18%; and bike – 6%. While such results reveal a strong tendency towards taxi use, 75% of participants indicated that they *would have* used the bus (a lot) more if it had been fully integrated as a mode (ESP Group, 2018).

MaaS Global, as its name suggests, aspires to provide a MaaS offer that is transferable with the notion of a 'roaming' option whereby the service can be used in other locations besides that originally registered for (similar to Uber). Nevertheless, Li and Voege note that "[c]urrently all available MaaS services target local residents" (Li and Voege, 2017: 98). This is significant in terms of understanding the (prospective) user: unless new to the area or facing changed circumstances, (prospective) users are already likely to be familiar with the local area in terms of their existing travel behaviour and may already have some prior knowledge or perception of how modal options in a MaaS service could compare. We address this further in Section 4. The market potential of a 'roaming' option may have its prospects limited by the localised nature of many of the trips people make overall.

Commentators refer to the prospect of MaaS intentionally nudging people's behaviours (Smith et al., 2018; Transport Committee, 2018). Whether or not such nudging is appropriate or might undermine user trust in the service merits consideration. The *ways* the mobility intermediary might nudge, and against what objectives, could be cause for concern. For instance the suggestion has been made that walking may be excluded or downplayed as a modal option (Transport Committee, 2018). This raises the question of how travel behaviour could be shaped by the type of mobility system beyond the private car that is now being developed – in the hands of both private sector companies and public sector bodies. We consider this next.

[9] Where a MaaS offering includes car-related elements (taxi rides, hire cars) this could presumably be addressed.
[10] https://www.navigogo.co.uk/.

2.5. Responsible innovation

Jittrapirom et al. (2017b) highlight concern over the possibility of the centralising effect of MaaS - mobility intermediaries being able to influence the mobility market in terms of both supply and demand and therefore price. If the mobility intermediaries are taking a return on investment for their shareholders, is this covered by the increase in efficiency they offer or is it to the detriment of the user (higher prices, less investment in services and safety etc.) and society as a whole? If MaaS does transition from niche towards mainstream there is a need to consider whether and how framework conditions can or should be set to ensure the impact of MaaS on mobility aligns with higher level goals for mobility in relation to sustainability and equity. In short, there is a need for responsible innovation. "Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present" (Stilgoe et al., 2013: 1570)[11].

Drawing upon experience of the UbiGo service in Gothenburg, Sochor et al. (2015b) highlight the need to consider three different perspectives in the provision of such services: user, commercial and societal. They point to a particular conflict of interest between a goal of reduction in car use and pursuit of profit for the mobility intermediary that derives from car sharing or car rental rather than from public transport use. We may question whether organisations are in a competitive or collaborative environment in any co-operation to deliver MaaS? The reluctance of bus operators to engage with MaaS has been noted[12], alongside concerns that public transport could be left behind by developments (Transport Committee, 2018). While MaaS offers the potential to contribute positively to sustainable mobility, as Transport for London has noted, "in doing this it must not undermine our priorities in London of promoting active travel and public transport usage, and encouraging a reduction in private cars" (TfL, 2018:2). The UK Department for Transport similarly sounds a note of caution over the potential negative effects of MaaS on its policy objectives (DfT, 2017). Mulley (2017) highlights the possibility of MaaS - through tailoring provision to each user's need - leading to increased demands being placed on our transport infrastructure if vehicle utilisation and occupancy levels are not improved. Pangbourne et al suggest that a MaaS portrayal as "unfettered freedom" for the individual consumer is "at odds with the challenge of satisfying simultaneous demand in a finite transport network" (Pangbourne et al., 2018: 39).

2.6. Summary

The prospect of MaaS is proving enticing to some and its proponents hail the opportunity to offer a truly compelling alternative to the private car. This comes at a time of notable underlying change in people's travel behaviours, particularly in relation to a decline in the proportions of young people who are qualified to drive. New supply-side intermediaries into the mobility system are at the forefront of potential for disrupting the incumbent mobility regime. Yet optimism and hype regarding disruption sit alongside the stability and familiarity of this incumbent regime and its established players. Co-operation from such established players, particularly public transport providers, is a pre-requisite of mobility intermediaries being able to offer a convenient alternative to the private car and one that is priced in such a way that it is attractive to both users but also the mobility intermediaries and the mobility service providers. Yet such co-operation is not necessarily forthcoming.

Fig. 1 provides a reminder of the different layers that are necessary in the mobility system beyond the private car if, through their integration, an attractive and convenient mobility service is to be on offer to the user. The prospect of MaaS is bound both to the need for integration and in turn for a favourable response from mobility system users. This response has implications for the commercial success of mobility intermediaries but also for the sustainability of the mobility system itself (highlighting the importance of responsible innovation). At this time, evidence from a small number of existing trials of MaaS globally is limited in relation to user reactions and behavioural response. While MaaS represents a move from car ownership to mobility access, it is not clear whether such access will continue to rely heavily upon car transport in the form of taxis, ride hailing and car hire. What becomes apparent from Fig. 1 is that MaaS is much more than the mobility intermediary. Providing people with a convenient alternative to the private car relies upon alternative and suitable means of transport being available, upon accessible information about them and upon ease of transaction in being able to use them. This is not something new. Pursuit of a more integrated transport system is longstanding. Section 3 now elaborates upon this and in turn goes into further detail regarding a user perspective on MaaS, setting out the different levels of integration in the *evolution* of MaaS.

3. The evolution of MaaS

In this section we provide a brief reminder of the evolution of travel information services and put forward a user-oriented taxonomy for how further evolutionary developments have been taking place and are intended to take place in the 'MaaS era'. From a user perspective, notwithstanding the *cost* of travel alternatives, the goal remains to develop a mobility alternative (or complement) to the private car that tends towards offering a convenient and seamless door-to-door travel experience that is not cognitively demanding to plan for and execute. This is central to defining our taxonomy.

[11] See also EPSRC's definition: "Responsible Innovation is a process that seeks to promote creativity and opportunities for science and innovation that are socially desirable and undertaken in the public interest" (https://epsrc.ukri.org/index.cfm/research/framework/).

[12] Some bus operators are, however, investing in their own on-demand services – e.g. https://www.arrivabus.co.uk/arrivaclick/.

3.1. MaaS before MaaS

The information services layer (Fig. 1) in the mobility system is far from new, albeit that it has evolved substantially. Paper timetables have been a feature of public transport for generations, as have route planning services for motorists. Computer-based systems to inform motorists have been around since the 1960s and 70s. 20 years ago 'ATIS' not 'MaaS' was the term of the day – Advanced Traveller Information Systems. Adler and Blue surmised that "[f]or ATIS to become more widespread and a permanent feature in the marketplace the technology must be affordable, provide understandable and believable information, be perceived as providing a personally valuable service, and complement within-day and day-to-day traveler behaviour" (Adler and Blue, 1998: 161). Earlier still, Barfield and Mannering (1993) had pointed to five key use-centric considerations needing attention: "(1) Do travelers use ATIS? (2) How and when do travelers use ATIS? (3) Why do travelers use ATIS (4) How do travelers perceive ATIS? (5) What are the consequences of ATIS?" (Adler and Blue, 1998: 160). These would appear pertinent considerations for MaaS today.

Two decades ago, information systems were rudimentary in nature by today's standards and unimodal in nature, with much of the ATIS literature focused upon driver information systems. The web had only just been invented. Yet this spelled a new phase of evolution for travel information services. In the early years of the new millennium, travel information websites were emerging that in some cases complemented existing telephone enquiry services. The nature of the web lent itself to the prospect of travellers more readily being able to bring unimodal information across modes together for themselves; or websites being developed that did this for them. Kenyon and Lyons referred to the latter approach as being multimodal traveller information (MTI) – "the provision of information about more than one mode of travel, within a single source" (Kenyon and Lyons, 2003: 5). Early examples of MTI services had been emerging – particularly through city authorities. Online journey planners also emerged that allowed individuals to plan a journey by a given mode.

Kenyon and Lyons suggested that an MTI approach would support travel planning for a mode already selected. They went on to propose that *integrated* multimodal traveller information (IMTI) could offer a better prospect for influencing mode choice through an approach that "automatically presents the user with information concerning different mode choice options in response to a particular journey specified by the user" (Kenyon and Lyons, 2003: 6). In 2000, traveline[13] was launched in the UK – providing a single point of contact service for bus, coach and train enquiries and journeys involving combinations of these. A second service then followed, delivered by the UK Government. The IMTI service Transport Direct was launched at the end of 2004 and provided what was considered a world first – an online national door-to-door multimodal journey planner covering car, public transport (and walking); and plane flights[14]. Delivery of the service was considered "a feat of achievement in terms of establishing access to, managing and interrogating the different and vast databases of information across modes and regions" (Lyons, 2006: 204). This unlocking of data access proved key to the emergence of services such as Google Transit[15] and the era of apps that was to follow.

This brief insight serves to suggest that MaaS is less of a new invention and more an innovation that extends, perhaps significantly, what came before it – a sense of evolution rather than revolution. The innovation is very much the mobility intermediary layer that builds upon what is outlined above, as well as capitalising upon the availability of the smart phone, to also achieve integration of booking, payment and ticketing and thereby move a step further towards the sense for the travelling public that seamless, convenient, door-to-door travel may be possible beyond use of the private car.

3.2. A MaaS taxonomy

The literature attests to the difficulty in defining what MaaS is and is not (Smith et al., 2018; Transport Committee, 2018). We suggest that this is symptomatic of a mobility system beyond the private car in which varying degrees of integration exist across the mobility services, information services and transaction layer and with the mobility intermediary reliant upon all three layers. Integration itself is also a phenomenon that eludes definitive understanding (Preston, 2012). However, in the context of this paper, the attempt by the UK Government in 1998 to address integration offers within it a useful articulation: "integration **within and between different types of transport** [original emphasis] - so that each contributes its full potential and people can move easily between them" (DETR, 1998: 8).

Inspired by Kenyon and Lyons (2003) (see above) and drawing upon the level 0–5 SAE taxonomy for automation of road vehicles[16], we put forward an equivalent taxonomy that we call the 'Levels of MaaS Integration (LMI) taxonomy' as shown in Fig. 2. This is contextualised and introduced below followed by a more detailed explanation of the levels within the taxonomy with examples of existing MaaS offerings (including those which pre-date the emergence of MaaS as a term). This is user-oriented and intended to help us in turn elaborate on whether, how and to what extent MaaS *in its new incarnations* offers significant new value to (prospective) users of the mobility system beyond the private car.

Having developed this, we became aware of a similar "typology of MaaS" developed by Jana Sochor and colleagues and presented at the first International Conference on Mobility as a Service in November 2017 (Sochor et al., 2017: 187). Due acknowledgement is

[13] http://www.traveline.info/.

[14] It later covered cycle route planning for some parts of the country. The service was closed on 30 September 2014 in the wake of other third party services emerging – its 'obituary' can be found here: https://www.gov.uk/government/news/transport-direct-website-closes-on-30-september-2014.

[15] https://maps.google.com/landing/transit/index.html.

[16] https://www.sae.org/standards/content/j3016_201609/.

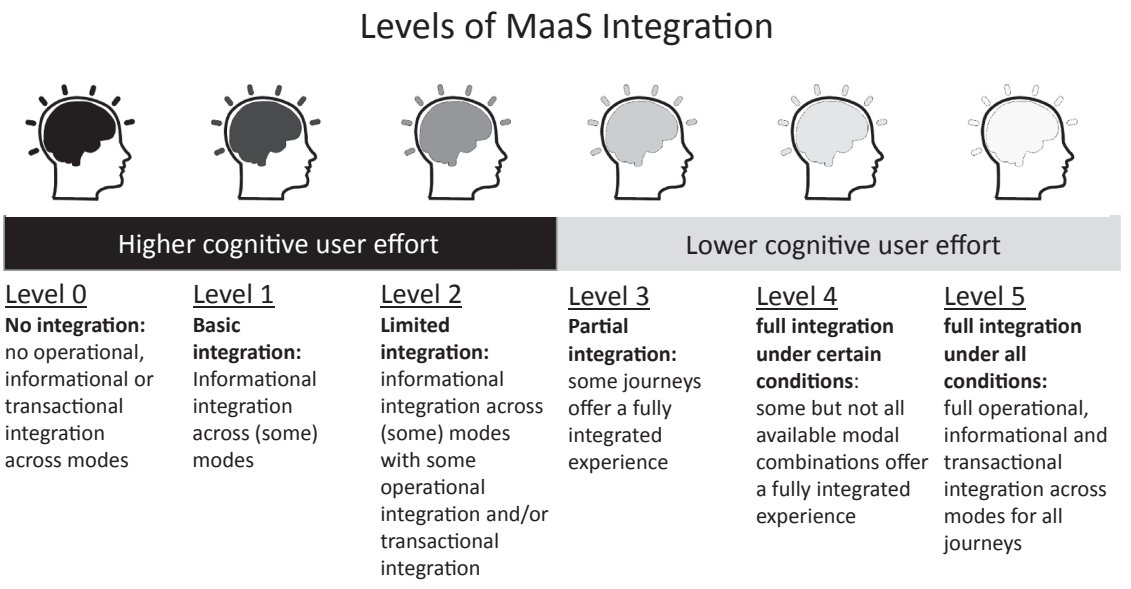

Fig. 2. Conceptualisation of the Levels of MaaS Integration (LMI) taxonomy (emulating 0–5 SAE taxonomy for automation of road vehicles).

therefore given to Sochor et al for recognising the value of trying to make sense of MaaS in this way and for being responsible for the first attempt to do so. In light of this, our taxonomy is included here for two reasons: (i) the multifaceted nature of a mobility system beyond the private car makes a fully exhaustive schema difficult or impossible to devise – an alternative interpretation helps elaborate this while serving to provide some reinforcement to the case set out by Sochor and colleagues in terms of similarities; and (ii) in this paper our interest is especially in the user perspective regarding the mobility system beyond the private car (while Sochor et al. (2017) focus upon the customer, provider and business perspectives[17]) and thus we include operational integration (the nature of door-to-door journey experience) and cognitive user effort.

A traveller faces physical, cognitive and affective (i.e. emotional) efforts in preparing for and undertaking a journey (Stradling, 2006). Such efforts can have a positive or negative consequence depending upon the individual and their travel circumstances. However, we suggest that a traveller would typically be seeking a door-to-door journey for which the cognitive effort is as low as possible (see Section 4). This calls for a journey that is convenient to plan, book, pay for and execute successfully. The private car is typically associated with such convenience – something MaaS seeks to emulate or surpass. Moving from lower to higher levels of MaaS integration in the taxonomy we posit corresponds to a lowering of cognitive effort associated with a reliance upon MaaS for fulfilment of mobility needs. In practice the degree of familiarity and predictability associated with a journey will affect what is needed from MaaS in terms of cognitive effort[18].

The taxonomy is centred upon the layers of the mobility system that underpin the mobility intermediary layer as depicted in Fig. 1 and the overall extent of integration provided that underpins the MaaS consumer offer. The levels can be further elaborated as follows:

Level 0 – no integration[19] – The transport system is experienced as a series of discrete modes. The MaaS offering is mode-specific and minimal. The UK's National Rail Enquiries[20] would be an example of this. There is integration across rail operators but not between rail and other modes[21]. Booking and payment for tickets is possible but only for rail. Point-to-point not door-to-door

[17] They note that "if a service does not deliver value to the customer or provider, and if the value cannot be captured by the business, then the service is not particularly relevant or sustainable" (Sochor et al., 2017: 191) – cf Lyons who "defines Effective Traveller Information Systems (ETIS) as: systems that achieve benefits for the traveller and/or the information systems' providers" (Lyons, 2001: 816).

[18] However, a user will have expended cognitive effort or relied upon others' cognitive effort in order to acquire a state of journey familiarity.

[19] Corresponds to Level 0 in Sochor et al. (2017) where this is also referred to as 'no integration' with Lyft rather than Uber as one example; Transport for London (TfL) is given as another – see our Level 2 example.

[20] http://www.nationalrail.co.uk/.

[21] With the exception of: (i) a 'PlusBus' ticket add-on to take a bus journey at the end of a train journey; and (ii) RailAir bus and coach services designed to link the National Rail network to UK airports (currently concentrated on Heathrow).

journeys are catered for. Uber[22] would be another example in its original incarnation of ride hailing. While this has what some might see as the hallmarks of MaaS in terms of its integration of information and payment through an app, it is unimodal. (However, in April 2018 Uber announced introduction of bike hire initially in San Francisco and Washington (having acquired bike share startup JUMP) and new partnerships in car rental and transit[23] as well as experimenting with an on-demand shuttle-like service called Express Pool (a variant of its UberPool ridesharing offer) - thus it looks set to move up through to higher levels of MaaS integration.)

Level 1 – basic integration[24] – The information layer integration spans some and possibly all of the different modes in the mobility system concerned but transactions to allow journey booking, payment and execution are mode specific (and separate). Traveline[25] in the UK would be an example of this – offering national door-to-door coverage of public transport modes and walk for journey planning but with no transactional element. Higher in level 1 is Google Transit with a journey planning service covering driving, transit, walking, cycling and (where available) flights[26]. It has no transaction layer[27].

Level 2 – limited integration – Building upon level 1, this level introduces elements of cross-modal transactional integration directly or indirectly and/or co-ordination between mobility services that contribute to operational integration. The UK-based Trainline[28] is an example of this where journey planning allows comparison between rail and coach options (where available) and in turn booking and payment. The TfL Journey Planner[29] for London is another example of Level 2 – when combined with the Oyster Card[30]. The Oyster Card is a pre-payment contactless card and can be used on all public transport modes in London but not for cycle hire, albeit that bike is a mode catered for in the Journey Planner. This is a high end Level 2 offering catering for door-to-door journeys in a public transport-rich environment. See also in Brussels the STIB-MIVB public transport (metro, tram, bus, train) journey planner service when combined with the MOBIB card[31].

Level 3 – partial integration – A single platform mobility intermediary allows journeys for more than one mode to be planned, booked and paid for and undertaken. Modal coverage is such that a seamless door-to-door experience is available in *limited* circumstances. This might be a precarious state for a mobility intermediary in that it offers the user a 'taste' of the possible without adequate coverage, or might be a transitional state towards Level 4. It reflects: (i) a geographic area where only some origin-destination pairs would reasonably be served by the mobility system beyond the private car under mobility intermediary control; and/or (ii) a multi-modal offering by the mobility intermediary that only partially serves most of its (prospective) individual users' mobility needs. In relation to (ii), Uber's move to combine ride hailing with bike and/or transit would be an example.

Level 4 – full integration under certain circumstances[32] – Cross-modal informational and transactional integration is achieved through a mobility intermediary. Operational integration (the seamless door-to-door journey experience) is dependent upon the mobility services layer of the mobility system beyond the private car. While points (i) and (ii) in Level 3 are addressed, some door-to-door journeys are still not able to be serviced in an integrated way either because of level of service issues or geographic coverage of the mobility services. Whim would be an example of this. Another example is the moovel app in Germany that provides journey planning, booking and payment covering car2go, mytaxi and Deutsche Bahn (in Stuttgart and Hamburg)[33].

Level 5 – full integration under all conditions[34] – MaaS integration provides a mobility system beyond the private car that is on a par with the convenience of the private car overall (accepting that for some journeys the private car would be less convenient and for others more) for an individual's mobility needs. While most travel is local, Level 5 accounts for longer distance (domestic) travel. This could be catered for by hire car use within a mobility intermediary package for less frequent longer distance travel, but should ideally allow for full (domestic) geographic coverage by further modes than only the hire car in the mobility intermediary's package. The aspiration behind MaaS Global and its 'roaming' concept relates to Level 5. This said, Level 5's reliance on operational integration may make it an unrealisable ideal.

3.3. Summary

The taxonomy highlights the 'mixed economy' of MaaS offerings that comprise the overall mobility system beyond the private car. MaaS is hard to define because it reflects an array of different offerings combining - to varying extents - operational, informational and transactional integration. New MaaS offerings may be targeting higher levels of overall integration but they enter what could be

[22] https://www.uber.com.

[23] https://techcrunch.com/2018/04/11/uber-gets-into-car-rentals-and-public-transit/.

[24] Corresponds to Level 1 in Sochor et al (2017) where referred to as 'integration of information' with Google as one example.

[25] http://www.traveline.info/.

[26] For transit, door-to-door journeys are possible including walk legs; for flights only airport to airport journeys are available.

[27] See also the now finished multimodal journey planner EU project 'SUPERHUB' - https://ec.europa.eu/digital-single-market/en/content/superhub-tailor-made-mobility.

[28] https://www.thetrainline.com/.

[29] https://tfl.gov.uk/plan-a-journey/.

[30] https://oyster.tfl.gov.uk/.

[31] https://www.stib-mivb.be/article.html?l=en&_guid=30af0085-2483-3410-5394-a71daf08acd1.

[32] Corresponds largely to Level 3 in Sochor et al. (2017), referred to as 'integration of the service offer' where elaborative commentary concerns provider and business perspectives, while here focus is upon user experience.

[33] https://www.moovel-group.com/en.

[34] This is rather different in focus to Level 4 in Sochor et al. (2017) - referred to as 'integration of societal goals' - where it is assumed that MaaS should be shaped with appropriate actors so as to pursue a system-optimal mobility solution beyond only meeting the needs of individual users.

considered an already busy marketplace. There is an important need for them to provide differentiation that can resonate with the user perspective. This is necessary both to compete or partner with existing MaaS offerings and to enhance the appeal of the mobility system beyond the private car, relative to the private car. Differentiation does not relate to the mobility intermediary layer alone. Indeed, we suggest, returning to Fig. 1, that the layers in the mobility system beyond the private car are reflective of a 'hierarchy of need' (Maslow, 1943, 1954) from the user perspective in terms of integration. Operational integration (infrastructure and vehicles layer underpinning the mobility services layer) is most fundamental. This is followed by informational integration (information services layer) and in turn by transactional integration (transaction layer). While we do not dismiss the important added value to the user of transactional integration as part of the MaaS offer, we suggest that operational integration and informational integration will remain principal determinants of 'bringing MaaS to the masses' (alongside the price of mobility). In Section 4 we therefore turn to examine the choice making behaviour of users in relation to these layers in the mobility system beyond the private car.

4. Travel choices and the role of information

Given the nascent nature of MaaS (at least in being labelled as such), it might not be a surprise that little commentary exists regarding user needs and behavioural response. Yet at the same time it seems remarkable that the user perspective and behavioural dimension have not been more central to the latest phase of MaaS innovation. As Pangbourne et al. (2018) suggest, perhaps this reflects a greater leaning towards technological determinism in the innovation. This said, the MaaS NaviGoGo trial in Scotland is an example of co-design in which the organisation YoungScot recruited people from the target demographic to help define the user requirements for the product[35].

While insight may be lacking that is specific to MaaS, there is a long history to the field of research into choice making and the role of information with regard to travel behaviour. This is noted by Chorus et al who suggest it "may provide an important first step in the understanding of its [next generation information provision] potential usage and effect" (Chorus et al., 2006: 128[36]). This section of the paper examines this to bring forward insights that may be of value to supporting the prospects for MaaS.

4.1. Why provide information?

The role of information can be summarised as fulfilling one or more of: (increased) awareness of the travel alternatives available for inclusion in the choice set; a more fully informed travel choice being made; and supporting the chosen option being successfully executed (Lyons, 2006). Empirical knowledge about information seeking and its effects is rather lacking, fragmented and very context specific (Chorus et al., 2006; Lyons et al., 2008; and Ben-Elia and Avineri, 2015). Ben-Elia and Avineri point out that "a common notion is that travel information supply will solve many transport related problems" (Ben-Elia and Avineri, 2015: 353). There has been a tendency within public authorities and industry to assume that improved information alone will unlock behaviour change (Chorus et al., 2006) with a 'build it and they will come' mentality (Lyons et al., 2008). Indeed, Lyons (2006) points to a pre-app era in which travel information service providers seemed to lack insight into the (expected) impact of their websites on demand for the corresponding mobility services, inferring an 'act of faith' regarding user demand and behavioural consequences. In terms of the wider context, changing behaviour can either arise from a change in the person (and their views) or a change in their situation (Stradling et al., 2000). Effecting change in behaviour can either be structural (changing the relative merits of different options in the choice set) or psychological (changing perceptions, beliefs and attitudes) (Graham-Rowe et al., 2011). Life events have received increasing attention in relation to their association with circumstances that prompt reconsideration of travel options (Clark et al., 2016b).

4.2. Choice setting

The choice setting for travel is diverse, concerning the purpose of travel and whether, when, where and how to travel. Travel circumstances may be familiar or unfamiliar with varying reliability/predictability. A trip may have arrival-time sensitivity/criticality. Choices can either be strategic/long-term (e.g. where to live, whether to buy a car) or tactical/short-term (e.g. how to travel today). Fundamentally, travel choices are situated in the context of people's lifestyles, patterns of activity pursuit and shared social norms (Stradling et al., 2000; Line et al., 2011; Nyblom, 2014) – something not necessarily appreciated in the more individualistic and rational analysis of travel choices and the role of information, yet which is recognised from a Practice Theory perspective: "[t]ravel patterns are naturally intimately bound to practices emerging from the overall coordination of daily life, and changes to these practices will affect and possibly change travel and travel planning practices" (Nyblom, 2014: 31). Stradling et al. (2000) emphasise the importance of context in contemplating a move away from private car use. They point out that many private car journeys have not replaced use of other modes – they are new trips to new destinations. While not confined to the private car, Ben-Elia and Avineri (2015) highlight the affective influence on choice making that can arise with emotional or symbolic attachment to a travel mode. The planning for, and use of, public transport is broadly seen to be cognitively more demanding than the car (Stradling et al., 2000; and Grotenhuis et al., 2007). Schmitt et al. (2013) give further attention to unfamiliar public transport travel, highlighting the increased cognitive effort involved. They also examine the 'primacy effect', "which suggests that first impressions of public transport have an important influence on attitudes and behaviour" (Schmitt et al., 2013: 1).

[35] https://www.the-espgroup.com/project/navigogo/.

[36] It is notable that this paper is itself now over 10 years old.

The choice setting also includes the decision maker and any cognitive or physical limitations they may have (Lyons et al., 2008; Lamont et al., 2013 and Waara et al., 2015) which could heighten or change the nature of information needs and access. Unless an information service is addressing a particular subset of the population then a design-for-all approach merits consideration. The portrayal of information itself is also part of the choice setting (Ben-Elia and Avineri, 2015). Popularised as 'nudging' by Thaler and Sunstein (2008), small features in information design can have effects (as noted earlier in Section 2). Avineri and Waygood (2013) empirically examined how framing one choice against another as either a loss or a gain can matter.

4.3. Choice mechanisms

There has been a long tradition – and one also subject to criticism - in travel behaviour analysis of adopting a neoclassical economics approach in which the choice maker is assumed to be rational and utility maximising in their behaviour ('homo economicus') (Chorus et al., 2006; Lyons et al., 2008; and Ben-Elia and Avineri, 2015). Psychological research "has unveiled systematic violations of the fundamental axioms of rational choice" (Ben-Elia and Avineri, 2015: 354) with a contrary notion of 'homo psychologicus' (Lyons et al., 2008) receiving attention. A series of phenomena have been identified. Todd (2007) points to the role of short-cut mechanisms or heuristics. Satisficing behaviour (Chorus et al., 2006) concerns an individual's willingness to accept a choice that is 'good enough'. Bounded rationality (Todd, 2007) is the notion that individuals are prepared to make such choices given constraints such as limited time, information and information processing ability. Todd points to the question of whether people would wish to be unboundedly rational if they could or whether a satisficing approach is preferred. Repeated experience of a choice setting and of a choice outcome can lead to habit where no conscious consideration is given to the choice concerned (Chorus et al., 2006). Social learning and social imitation (Todd, 2007) highlights the importance of moving beyond the individualistic frame of travel behaviour (Nyblom, 2014). As individuals, our heuristics can include learning from and copying the choices and behaviours of others. Loss aversion reflects a behavioural phenomenon whereby an individual can favour known states (familiar choices and outcomes versus those which are less familiar and ambiguous) (Ben-Elia and Avineri, 2015).

4.4. Demand for information

Demand for information is affected by how well informed an individual currently believes they are versus how well informed they consider they need to be or are able to be. There is an effort-accuracy trade-off to be weighed up (Chorus et al., 2006) in terms of the input required to become better informed versus the (anticipated) improvement in outcome. Related to this is the notion of anticipated regret or regret aversion (Ben-Elia and Avineri, 2015). If an individual anticipates that without seeking further information the outcome decision could have adverse consequences (e.g. missing an interview) then they are motivated to become more informed.

Journey situations that are familiar and predictable are associated with low demand for use of (formal) information services, with past experience and heuristics able to be relied upon to achieve satisfactory outcomes (Lyons, 2006; Lyons et al., 2008). The reverse is also true – and demand is especially high at times of transport service disruption. Nyblom (2014) provides a reminder, however, that the richness of everyday life involves multiple information sources where degrees of information use set against extent of familiarity/predictability are less clear. Just as heuristics affect the demand for information, it appears they also affect which information sources are used – people have favoured, familiar and satisfactory information sources that are sufficient for their needs, and may indeed have back-up sources they turn to beyond these (Farag and Lyons, 2008).

Contrary to a widespread assumption that provision and awareness of information sources can be the route to behaviour change, Farag and Lyons found the reverse to be true (in the context of online use of public transport information relating to long distance journeys) – "[p]ublic transport use and PT information use are closely connected, with travel behaviour having a stronger impact on information use than vice versa" (Farag and Lyons, 2012: 82). This led to a conclusion that demand for information use derives from a propensity to consider using public transport (and not the other way around) with the implication that marketing of public transport (addressing the product, its price, position and promotion) was key (as opposed to (only) promoting the information service).

4.5. Summary and a MaaS behavioural schema

User engagement with a new MaaS offer is not a foregone conclusion. Such an offer could represent an improvement to the mobility services available or to the informational and transactional interface to those services. This may prompt the user to engage if they are aware of the improvement. However, if they are already satisfied with their existing mobility behaviours and any related existing MaaS offer, there may not be any motivation to review and revise their engagement with the mobility system beyond the private car. Other prompts – notably change in circumstances for the user themselves and in turn a changed choice setting - could lead to consideration of the new (or existing) MaaS offer. In such consideration, choice mechanisms would be at work in determining the outcome of that consideration which may or may not lead to changed behaviour.

Fig. 3 sets out a behavioural schema to reflect what might be expected from a user perspective in determining whether or not to engage with, and potentially adopt, a new MaaS offer such as the launch of Whim in the West Midlands in the UK. The new MaaS offer may be an existing one which is *new to the individual* or a *newly introduced* MaaS offer. The schema is illustrative and for simplicity it is assumed that it is based on an individual prospective user as opposed to consideration in relation to an individual's association with a household or close friends wherein there may be co-operative or inter-dependent mobility behaviours (though we suggest this is an important area for future examination given the level of financial commitment expected of the user - £349/month in

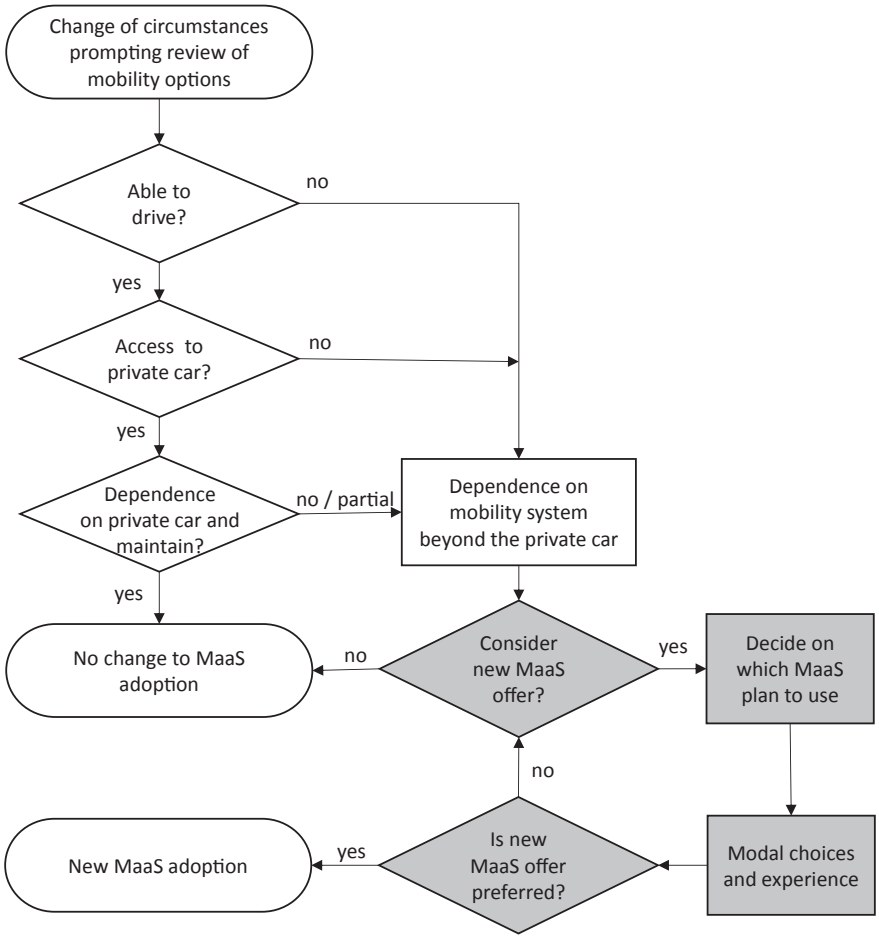

Fig. 3. Individual choice making and the adoption of MaaS.

the case of the Whim Unlimited offer).

The depiction begins with a change of circumstances (change in mobility requirements, mobility attitudes or mobility system) prompting a review of mobility options. The initial contextual consideration is whether the individual has access to the private car (including being a passenger in someone else's private car). If they do *not* then by implication they have dependence on the mobility system beyond the private car (unless this is remedied by learning to drive and/or gaining access to a private car). If they do, then a dependence on the private car *could* be preferred, sufficient and maintained such that little or no (further) dependence on the mobility system beyond the private car is required (termination: 'no change to MaaS adoption'). Alternatively, either in spite of access to the private car or complementary to it, there may be a choice or necessity to (also) depend upon the mobility system beyond the private car. This dependence could be full (i.e. no access to private car) or partial (e.g. household car ownership level reduced and/or access to a private car may be shared with another household member).

With a dependence upon the mobility system beyond the private car, the individual may be able to fulfil their mobility requirements through their existing MaaS integration level adoption, with either a lack of awareness of, or a conscious decision not to consider, the new MaaS offer (termination: 'no change to MaaS adoption'). They may be aware of, but decide not to consider, the new MaaS offer (termination: 'no change to MaaS adoption'). If the individual chooses to consider the new MaaS offer they would decide on which MaaS service plan (if there is more than one) within this offer to use (or consider using). In the context of a chosen plan the individual would weigh up (and potentially experiment with and experience) their modal choices. This would inform whether the new MaaS offer is preferred given their change in circumstances. If so then this offer is taken up (termination: 'new MaaS adoption'). If it is not preferred, the individual may consider the MaaS offer again for a different service plan within the offer; alternatively they may end this consideration of the new MaaS offer (termination: 'no change to MaaS adoption').

5. Conclusions

In name, MaaS is a new and hyped phenomenon whose potential is at the early stages of being explored through a growing number of trials in different parts of the world. While it holds the promise of providing a compelling alternative to the private car,

distinctive in its proposition is the ability to harness digital connectivity to put convenience in the hands of the user in the form of an App that enables multi-modal planning, booking and payment for travel. This is significant. However, what we have shown in this paper is that *firstly*, as a form of disruption to the incumbent mobility regime, MaaS faces challenges in brokering the co-operation amongst supply-side actors in the mobility system necessary to enable its effective operation. There is resistance and inertia to be overcome. *Secondly*, the paper has highlighted the important distinction between the mobility intermediaries (those organisations seeking to be the interface between the user and the mobility system beyond the private car) and the mobility system as a whole, within which there are a number of other important layers that *together* make up MaaS. These layers constitute a hierarchy of user need. Fundamental in this hierarchy is the existence of viable travel alternatives to the private car. Only then do the higher levels concerning information for journey planning and booking and payment facilities come into their own. *Thirdly*, and distinctly from a user perspective, we have put forward the Levels of MaaS Integration (LMI) taxonomy through which we highlight that, far from being a nascent phenomenon, the pursuit of more convenient and seamless door-to-door travel (from mobility service provision through journey planning to booking, payment and execution) is longstanding. MaaS is an evolving phenomenon centred upon achieving increased operational, informational and transactional integration in order to provide a user experience of MaaS to rival that of the private car. It exists in a number of guises at different levels of integration. *Fourthly*, the paper has more closely examined factors affecting how people make travel choices and put forward a behavioural schema in order to articulate a user perspective on the prospect for consideration and adoption of any new MaaS offer into the mobility marketplace. The offer in and of itself may not generate user demand – users must be presented with a change in circumstances sufficient to prompt them to consider the MaaS offer.

What then does taking a user perspective reveal about the prospects for MaaS and in particular the prospects for new mobility intermediaries? User choice about how to travel as well as how to plan, book and pay for that travel becomes a key factor in the level of success MaaS may achieve in providing an alternative or complement to the private car. It may be that MaaS (especially that which we refer to as 'level 4′ integration) is set to capitalise on new dynamics in travel behaviour change that are in any case at play and producing what has been called 'asymmetric churn' (Saleh and Farrell, 2007) whereby quite substantial changes both towards and away from reliance upon the private car for mobility are showing a net change in favour of less car dependence. However, if this is the case then the mobility intermediary must have a clear value proposition, over and above other MaaS offerings at different levels of integration, that generates and retains demand. The trend in urbanisation and a young, technology savvy generation less inclined to hold driving licences is one example of an enticing market for MaaS – presupposing that this market is not already sufficiently well-served by existing (lower level) MaaS players.

Mobility intermediaries are reliant upon the underpinning layers of the mobility system beyond the private car – especially the mobility services layer (itself underpinned by the infrastructure and vehicles layer) which may become a particularly challenging consideration in terms of scaling up and providing a level of mobility service that is acceptable to end users. This layer contains multiple modes not all of which offer the same appeal to private and public sector interests. Popularity of MaaS seems possible through a growth in the density, convenience and affordability of ride hailing in some cities. This may serve (some) individuals users well and further encourage behaviour change away from dependence upon the *private* car alongside supporting a business model for mobility intermediaries. However, this may also constitute (alongside a car hire offer) what could be seen as 'perpetuation of car dependence by stealth' (potentially exacerbated by developments in vehicle automation) and run counter to sustainability (and equity) goals. To provide some rebalancing of the choice set in the mobility system beyond the private car, it is important that public authorities seek to exert some influence in setting framework conditions for MaaS while working with non-car mobility service providers to invest in enhancing the availability and relative attractiveness of their modes in the traveller's choice set. Another issue (beyond the coverage of this paper) and one which will be important to resolve is who holds responsibility for the level of service experienced by the user and who provides redress if problems arise in a MaaS offering involving both a mobility intermediary and mobility service providers?

Mobility intermediaries may not face the growing demand for MaaS that they anticipate if: underlying behavioural dynamics are not as strong; the supply side of mobility service providers cannot respond to changing demand; or trial participants and early adopters are not representative of a wider appetite from the travelling public. Behaviour change programmes of the past have managed to show some success at pilot/scheme stage but not necessarily achieved an effective scaling up subsequently. We suggest that a strong need exists for market research to better understand (prospective) MaaS user attitudes, needs and choice making behaviour. Without this to underpin business planning and development, the enthusiastic drive to deliver MaaS may falter or face unanticipated challenges that could have been foreseen and accounted for.

We suspect that a rather longstanding presumption in the MaaS evolution that propensity to change behaviour in the mobility services layer stems from propensity to use the information services layer could still prevail if not challenged. Mobility intermediaries and their collaborators in the public and private sector should consider closely the user perspective and prioritise the importance of getting the product in the mobility services layer right as a precursor to, or alongside, addressing price and promotion through the mobility intermediary layer itself.

References

Accenture (2018). Mobility as a Service – Mapping a route towards future success in the new automotive ecosystem. Accenture. Available at: https://www.accenture.com/gb-en/insight-mobility-automotive-ecosystem.

Adler, J.L., Blue, V.J., 1998. Toward the design of intelligent traveler information systems. Transport. Res. C 6, 157–172.

Avineri, E., Waygood, E.O.D., 2013. Applying valence framing to enhance the effect of information on transport-related carbon dioxide emissions. Transport. Res. Part A: Policy Pract. 48, 31–38.

Axhausen, K.W., Simma, A., Golob, T., 2000. Pre-commitment and Usage: Season Tickets, Cars and Travel. Paper presented at the RSA World Congress 2000, Lugano, May.
Barfield, W., Mannering, F., 1993. Behavioral and human factors issues in advanced traveler information systems. Transport. Res. C 1 (2), 105–106.
Ben-Elia, E., Avineri, E., 2015. Response to travel information: A behavioural review. Transport Rev. 35 (3), 352–377.
Black, C.M., 2008. Fringe benefits tax and the company car: Aligning the tax with environmental policy. The University of Sydney, Sydney Law School Legal Studies Research Paper No. 2008 08/60.
CAR, 2016. The Impact of New Mobility Services on the Automotive Industry. Centre for Automotive Research, August. Available at: https://www.cargroup.org/wp-content/uploads/2017/02/The-Impact-of-New-Mobility-Services-on-the-Automotive-Industry.pdf.
Chatterjee, K., Goodwin, P., Schwanen, T., Clark, B., Jain, J., Melia, S., Middleton, J., Plyushteva, A., Ricci, M., Santos, G., Stokes, G., 2018. Young People's Travel – What's Changed and Why? Review and Analysis. Report to Department for Transport. UWE Bristol, UK. Available at: http://eprints.uwe.ac.uk/34640/.
Chorus, C.G., Molin, E.J.E., van Wee, B., 2006. Use and effects of advanced traveller information services (ATIS): a review of the literature. Transport Rev. 26 (2), 127–149.
Clark, B., Lyons, G., Chatterjee, K., 2016b. Understanding the process that gives rise to household car ownership level changes. J. Transport. Geogr. 55, 110–120.
Clark, B., Chatterjee, K., Melia, S., 2016a. Changes in level of household car ownership: The role of life events and spatial context. Transportation 43 (4), 565–599.
Dedehayir, O., Steinert, M., 2016. The hype cycle model: A review and future directions. Technol. Forecast. Soc. Chang. 108 (2016), 28–41.
DETR, 1998. A new deal for transport better for everyone. Transport White Paper, Department of the Environment, Transport and the Regions, July, TSO, London.
DfT, 2017. Written evidence submitted by Ito World Ltd (MAS0049). Submission to the UK Parliament's Transport Committee inquiry into Mobility as a Service, December.
ESP Group, 2018. NaviGoGo – Scotland's first MaaS Pilot. ESP Group, September. Available at: https://www.youngscot.net/wp-content/uploads/2018/09/NaviGoGo-Pilot-report.pdf.
Farag, S., Lyons, G., 2008. What affects use of pretrip public transport information? Empirical results of a qualitative study. In: Transportation Research Record: Journal of the Transportation Research Board, 2069. Transportation Research Board of the National Academies, Washington, D.C., pp. 85–92.
Farag, S., Lyons, G., 2012. To use or not to use? An empirical study of pre-trip public transport information for business and leisure trips and comparison with car travel. Transport. Policy 20, 82–92.
Geels, F., 2012. A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. J. Transport. Geogr. 24, 471–482.
Giesecke, R., Surakka, T., Hakonen, M., 2016. Conceptualising mobility as a service – A user centric view on key issues of mobility services. Proc. Eleventh International Conference on Ecological Vehicles and Renewable Energies (EVER).
MaaS Global, 2017. Written evidence submitted by MaaS Global Oy (MAS0026). Submission to the UK Parliament's Transport Committee inquiry into Mobility as a Service, December.
Goodwin, P., Van Dender, K., 2013. Peak car-themes and issues. Transport Rev. 33 (3), 243–254.
Graham-Rowe, E., Skippon, S., Gardner, B., Abraham, C., 2011. Can we reduce car use and if so, how? A review of available evidence. Transport. Res. A: Policy Pract. 45, 401–418.
Grotenhuis, J.-W., Wiegmans, B.W., Rietveld, P., 2007. The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings. Transport. Policy 14, 27–38.
Heikkilä, S., 2014. Mobility as a Service – A Proposal for Action for the Public Administration, Case Helsinki. MSc dissertation, Aalto University, Finland. Available at: https://aaltodoc.aalto.fi/handle/123456789/13133.
Hensher, D., 2017. Future bus transport contracts under a mobility as a service (MaaS) regime in the digital age: Are they likely to change? Transport. Res. A: Policy Pract. 98, 86–96.
Hietanen, S., 2014. Mobility as a Service—The new transport model? Eurotransport 12 (2), 26–28.
Ito World, 2018. Written evidence submitted by Ito World Ltd (MAS0049). Submission to the UK Parliament's Transport Committee inquiry into Mobility as a Service, March.
Jittrapirom, P., Caiati, V., Feneri, A.M., Ebrahimigharehbaghi, S., Alonso-González, M.J., Narayan, J., 2017a. Mobility as a service: A critical review of definitions, assessments of schemes, and key challenges. Urban Planning 2 (2), 13–25.
Jittrapirom, P., Marchau, V.A.W.J., Meurs, H., 2017b. Dynamic adaptive policymaking for implementing mobility as a service. Proc. Eur. Transport Conf.
Kamargianni, M., Li, W., Matyas, M., Schäfer, A., 2016. A critical review of new mobility services for urban transport. Transport. Res. Procedia 14, 3294–3303.
Karlsson, I.C.M., Sochor, J., Strömberg, H., 2016. Developing the "service" in mobility as a service: Experiences from a field trial of an innovative travel brokerage. Transport. Res. Procedia 14, 3265–3273.
Kenyon, S., Lyons, G., 2003. The Value of Integrated Multimodal Information and its Potential Contribution to Modal Change. Transport. Res. Part F - Traffic Psychol. Behav. 6 (1), 1–21.
Lamont, D., Kenyon, S., Lyons, G., 2013. Dyslexia and mobility-related social exclusion: the role of travel information. J. Transport. Geogr. 26, 147–157.
Li, Y., Voege, T., 2017. Mobility as a Service (MaaS): Challenges of Implementation and Policy Required. J. Transport. Technol. 7, 95–106.
Linden, A., Fenn, J., 2003. Understanding Gartner's Hype Cycles. Strategic Analysis Report No R-20-1971. Gartner Inc, May, Stamford.
Line, T., Jain, J., Lyons, G., 2011. The role of ICTs in everyday mobile lives. J. Transport. Geogr. 19 (6), 1490–1499.
Lyons, G., 2001. From advanced towards effective traveller information systems. In: Hensher, D.A. (Ed.), (2001) Travel Behaviour Research: The Leading Edge. Pergamon, pp. 813–826.
Lyons, G., 2006. The role of information in decision-making with regard to travel. Intell. Transport Syst. 153 (3), 199–212.
Lyons, G., Avineri, E., Farag, S., 2008. Assessing the demand for travel information: do we really want to know? Proc. European Transport Conference, Leeuwenhorst Conference Centre, The Netherlands.
Lyons, G., Mokhtarian, P., Dijst, M., Böcker, L., 2018. The dynamics of urban metabolism in the face of digitalization and changing lifestyles: Understanding and influencing our cities. Resour. Conserv. Recycl., 132: Special Issue Urban Infrastruct. Syst. Sustain. Resour. Manage. 246–257.
Marsden, G., et al., 2018. All Change? The future of travel demand and the implications for policy and planning. The First report of the Commission on Travel Demand. Available at http://www.demand.ac.uk/wp-content/uploads/2018/04/FutureTravel_report_final.pdf.
Maslow, A.H., 1943. A theory of human motivation. Psychol. Rev. 50 (4), 370–396.
Maslow, A.H., 1954. Motivation and personality. Harper and Row, New York.
Mulley, C., 2017. Mobility as a Services (MaaS) – does it have critical mass? Transport Rev. 37 (3), 247–251.
Nyblom, Å., 2014. Making plans or "just thinking about the trip"? Understanding people's travel planning in practice. J. Transport. Geogr. 35, 30–39.
Pangbourne, K., Stead, D., Mladenovic, M., Milakis, D., 2018. The case of Mobility as a Service: A critical reflection on challenges for urban transport and mobility governance. In: Marsden, G., Reardon, L., (Eds.) (2018). Governance of the smart mobility transition. (Chapter 3). pp. 33–48. Emerald Points.
Preston, J., 2012. Integration for Seamless Transport. Discussion paper for the 2012 Summit of the International Transport Forum, on Seamless Transport: Making Connections, 2–4 May, Leipzig, Germany.
Saleh, W., Farrell, S., 2007. Investigation and analysis of evidence of asymmetric churn in travel demand models. Transport. Res. Part A: Policy Pract. 41, 691–702.
Schmitt, L., Currie, G., Delbosc, A., 2013. Exploring unfamiliar public transport travel using a journey planner web survey. Proc. Australasian Transport Research Forum, 2-4 October, Brisbane, Australia.
Seely, A., 2002. Taxing company cars. Research Paper 02/10. House of Commons Library.
Smith, G., Sochor, J., Karlsson, M., 2018. Mobility as a Service: Development scenarios and implications for public transport. Res. Transport. Econ. 69, 592–599.
Sochor, J., Strömberg, H., Karlsson, I.C.M., 2015b. Implementing mobility as a service: Challenges in integrating user, commercial, and societal perspectives. In: Transportation Research Record: Journal of the Transportation Research Board 2536(4). Transportation Research Board of the National Academies, Washington, D.C., pp. 1–9.

Sochor, J., Arby, H., Karlsson, M., Sarasini, S., 2017. A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of societal goals. Proc. ICoMaaS – 1st International Conference on Mobility as a Service.

Sochor, J., Strömberg, H., Karlsson, M., 2015a. An innovative mobility service to facilitate changes in travel behavior and mode choice. In: Proc. 22nd ITS World Congress, Bordeaux, France, 5–9 October.

Stilgoe, J., Owen, R., Macnaghten, P., 2013. Developing a framework for responsible innovation. Res. Policy 42, 1568–1580.

Stradling, S., Meadows, M.L., Beatty, S., 2000. Helping drivers out of their cars - Integrating transport policy and social psychology for sustainable change. Transport. Policy 7, 207–215.

Stradling, S., 2006. Moving Around: Some Aspects of the Psychology of Transport. Review Commissioned for the Foresight 'Intelligent Infrastructure Systems' project, Office of Science and Technology, Department for Trade and Industry, London.

TfL, 2018. Written evidence submitted by Transport for London (MAS0045). Submission to the UK Parliament's Transport Committee inquiry into Mobility as a Service, January.

Thaler, R.H., Sunstein, C.R., 2008. Nudge: Improving decisions about health, wealth, and happiness. Yale University Press, New Haven.

Todd, P.M., 2007. How much information do we need? Eur. J. Oper. Res. 177, 1317–1332.

Transport Committee, 2018. Oral evidence: Mobility as a Service, HC 590. Transcript of oral evidence session on 23 April as part of the Committee's Mobility as a Service inquiry.

Uber, 2017. Written evidence submitted by Uber (MAS0015). Submission to the UK Parliament's Transport Committee inquiry into Mobility as a Service, December.

Viaqqio, 2017. Written Evidence submitted by Viaqqio Ltd (part of the ESP Group) (MAS0005). Submission to the UK Parliament's Transport Committee inquiry into Mobility as a Service, December.

Waara, N., Brundell-Freij, K., Risser, R., Ståhl, A., 2015. Feasible provision of targeted traveler information in public transportation: Segmentation based on functional limitations. Transport. Res. A: Policy Pract. 74, 164–173.