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Transportation Research Procedia 00 (2017) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

The role of new mobility services in sustainable urban transport strategies

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Abstract

Objective European cities are expected to develop and update Sustainable Urban Mobility Plans (SUMPs), for which the provision of public transport forms a key part. New mobility services are expanding rapidly, but there is as yet little information on their performance. They are typically offered by the private sector, and potentially result in services which compete with, as well as complement, conventional public transport. This raises new challenges in both policy formulation and governance. Drawing on an earlier case study of York, England, this paper outlines the opportunities and challenges which new mobility services will present for public transport policy, and the ways in which the wider mix of sustainable modes might best be governed.

Methods The paper starts by reviewing the range of new mobility services which are emerging, and the limited evidence on their performance. It uses the earlier case study of York to identify eight challenges which any future public transport strategy must address. It then considers the potential of each conventional and new mobility service to address these challenges. On that basis it proposes a corridor-based approach to determining the most appropriate applications of each of the available new mobility services. In a final section it reviews the governance options and powers available to the city and suggests how they might best be applied.

Results The challenges identified include the need to increase the sustainable mode share, incomplete spatial and temporal coverage, and significant delays to bus services, all of which might be aggravated by future population increases. We conclude that demand-responsive bus services, bike sharing and, potentially, car sharing offer the greatest potential for satisfying unmet needs and providing an alternative to the car. They will need to be

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Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

complemented by more intensive demand management. We propose an analytical approach for determining the most appropriate policy mix for each movement corridor. The most appropriate governance model might well involve the development of a Quality Access Partnership, with the city taking the lead in any such structure and in the application of hard and soft powers, and with Mobility as a Service providing a basis for integration. It will be important for national governments to develop a regulatory framework in which such a governance model can operate.

Discussion The conclusions should be relevant to other European cities and, potentially to developed cities elsewhere. They demonstrate the need at a national level for greater regulatory control of new mobility services and at a local level for stronger long-term political commitment.

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Keywords: public transport; urban transport; new mobility services

1. Introduction

In 2014, the European Commission published guidance on the development of Sustainable Urban Mobility Plans (SUMPs) (Rupprecht Consult, 2014). The guidance emphasises that a SUMP should be holistic in its treatment of the full range of possible policy interventions. A key element in any SUMP strategy will be the provision of public transport which, alongside improvements to walking and cycling, should offer alternatives to car use, and hence contribute to improved accessibility and reduced congestion and environmental damage (UITP, 2017). Most public transport is still based on the use of conventional buses, trams and heavy rail, and there is ample evidence of the contributions of each, through factors such as frequency, coverage, reliability and fares, to the performance of a transport strategy (May et al, 2018a).

However, the nature of public transport is changing rapidly with the development of new mobility services. For example, shared taxis, demand-responsive buses, shared cars and shared bikes are able to offer a wider range of mobility options, which may compete with, or extend the range of conventional public transport. New approaches to charging for public transport, collecting fares and providing information can affect the awareness and acceptability of the range of public transport options. And Mobility as a Service (MaaS (Hoadley, 2017)) has the potential to offer the user a simpler, integrated way of choosing, booking and paying for the most appropriate combination of modes for a given journey.

City authorities face two difficulties in incorporating such innovations into their SUMPs. Firstly, there is still very limited information on their performance and the transferability of that performance between contexts. Secondly, most are being offered by third parties who are not in the public sector, are not typically involved in the provision of conventional public transport, and who may wish to compete with, rather than complement, existing services. This introduces challenges for option generation, evaluation and above all governance in the preparation of SUMPs.

This paper aims to consider these challenges, and how they might most effectively be overcome, in the incorporation of new mobility services into SUMPs. In doing so it draws on an earlier a case study of the city of York, England (May and Marsden, 2018). In Section 2 we summarise the literature on SUMPs and option generation, on new mobility services and on governance. Section 3 briefly outlines the case study, and identifies the eight challenges which its conventional public transport service faces. In Section 4 we review the full range of existing and new mobility service options, assess their potential contributions to the eight challenges, and suggest how they might best be integrated into an overall strategy. Section 5 considers possible governance options, and Section 6 presents our conclusions and their implications for policy.

2. A review of the literature

The SUMP guidance (Rupprecht Consult, 2014) satisfied one of the commitments of the Commission's Action Plan on Urban Mobility (EC, 2010) which envisaged that all European cities over a certain size would be expected to produce a SUMP, that Member States would be encouraged to provide platforms to support this, and that European funding for urban transport might in future be predicated on the availability of a SUMP.

The guidance emphasises that a SUMP should be: based on a vision and policy objectives related to sustainability; integrated in its consideration of different policy sectors and tiers of government; holistic in its treatment of the full range of possible policy interventions; cost-effective in its use of scarce resources; and founded on a participatory approach involving both citizens and stakeholders (Rupprecht Consult, 2014). Subsequent documents have expanded the guidance on participation (Rupprecht Consult, 2016); governance (POLIS and WYCA, 2016); measure selection (May, 2016) and evaluation (Gühnemann, 2016).

The advice on measure selection (May, 2016) draws on the principles of option generation: that failure to consider the full range of possible solutions to a problem can result in sub-optimal outcomes and waste of resources (Eddington, 2006); and that policy makers need first to define their objectives, then review all the types of policy measure which might contribute to those objectives, and subsequently package them in ways that enhance the cost-effectiveness of the overall strategy and overcome the barriers to its implementation. These principles, which help lead to sustainable policy packages (Givoni et al, 2013), have now been embedded into the option generation facility included in the Knowledgebase on Sustainable Urban Land use and Transport (KonSULT: www.konsult.leeds.ac.uk) (May et al, 2018a), while the advice on measure selection (May, 2016) illustrates to cities how they can make best use of this facility.

The transport system is, however, in the midst of a significant change. Shaheen et al. (2018) identify the types of new mobility service, and suggest that "Transportation is undergoing a transformative revolution. Trending technologies and competitive markets are accelerating innovation in the field at faster rates than previously predicted". Whilst it has proven possible to simulate highly automated and shared transport futures where people give up their cars (e.g. ITF, 2015), these are theoretical results, and much will depend on the practical and regulatory transition from the current transport mix.

Shibayama and Emberger (2018) review the range of emerging mobility services and technologies, and categorise them under four headings: vehicle sharing; ride sourcing; online services; and vehicle technologies. We use a similar categorisation in this paper, but exclude vehicle technologies, whose impacts we have addressed elsewhere (May et al, 2018b). We also omit some of the more marginal developments listed by Shibayama and Emberger, including peer to peer car sharing, community services and motorcycle sharing. Conversely we add demand-responsive micro-transit services. Our final categorisation is:

- Car sharing
    - Station based
    - Floating
- Bike sharing
    - Docked (station based)
    - Floating (dockless)
- Ride sourcing
- Demand-responsive micro-transit
    - Taxi-based
    - Bus-based
- Online services
    - Mobility as a Service (MaaS).

It is far from clear which of these innovations will be successful in different contexts, alone and in combination. The degree of success will, to some extent, be the result of planning actions taken by local and national governments (Docherty et al., 2017). Nonetheless, the changing nature of the options to be considered is having a significant impact on what to plan for and how to plan for it.

Are these innovations really any different from those which cities currently employ and which form the basis of the SUMP guidance? For some innovations the answer is no. Mobility as a Service (Hoadley, 2017), for example, brings together information, travel options and payment across all modes of transport in a bundled tariff. However, this is really an extension of the sorts of systems in place in many cities. For other innovations the answer is most definitely yes. Companies such as *Uber* and *Lyft* and *O-Bike* have launched in cities with very little discussion with the local authorities and have set up in deliberate and direct competition to existing providers and with only limited thought as to where they fit in the overall mobility system (Flores-Dewey and Rayle, 2018). That is not to say that such services might not benefit some consumers, indeed they must do in order to survive. However, as Circella and Alemi (2018) show, this can often be through a redistribution of users between modes with *Uber* and *Lyft* taking some people out of their cars but also some people from public transport and from short walking trips.

Whilst these innovations may still only be at the trial and partial implementation phase, they did not feature as an option in SUMPs five years ago. There is a need to think about where they fit into the urban system because they are coming, whether they were planned by transport planners or not (ITF, 2018). Unfortunately, empirical evidence on their performance is still very limited. We summarise what is known in the following paragraphs.

Car sharing: station based Car sharing, in which vehicles are owned by a provider, based at fixed "stations" and used by individual club members for a fee, have been in operation for two decades. There is ample evidence that they reduce the size of the vehicle fleet and that, by charging at the point of use, they reduce the modal share for car use (Becker et al, 2017). As a result, road space is used more efficiently, and parking requirements are reduced. A recent survey of six operators' services in London (SDG, 2017) found that each shared car replaced 10.5 privately owned cars, and that only 24% of members owned cars, as compared with 57% of all London households. On average, car club members travelled 3035 miles per year by car, as compared with 6900 miles for all car owners. Car club vehicle occupancy averaged 2.6, as opposed to 1.6 for all cars; car club cars were more likely to be used for leisure and personal business, and less for commuting.

Car sharing: floating Since 2011, car share schemes have been introduced in which the cars are available within a designated area, using GPS-enabled identification of available cars and online booking. Most, such as *car2go* and *Drive Now*, have been introduced by automobile manufacturers as an extension to their markets. These floating schemes remove the constraint of having to travel to and from a fixed station, and should in principle make car sharing a more attractive alternative to car ownership as well as to conventional public transport. However, there is still only very limited evidence on their impacts (Becker et al, 2017).

Bike sharing: docked Bike sharing, in which users can use a bicycle for a time-based electronic payment provided that it is collected from and returned to one of a number of fixed docking stations, have been in operation since 2001, and can now be found in many cities around the world. In some schemes, individual bikes are reportedly used 10 to 15 times per day and may travel as much as 10,000km per year. Early schemes such as *Velo'v* in Lyon attracted most patronage from riders who would otherwise have walked or used public transport, but more recent evidence suggests that bike sharing is now offering an alternative to car use. Studies in the US found that 8% of bike share users in Washington DC, and 20% in Minneapolis would have used the car (Fishman, 2015). More recently surveys of UK bike share users show that 25% use bike share in combination with public transport and that 23% used a bike share bike instead of a car for their trip (CoMoUK, 2018). Some recent schemes have introduced the option of electric bike share, with bikes recharged at the bike stations.

Bike sharing: floating Docked bike share schemes have the same disadvantage as station-based car sharing of needing to return the bike to a fixed station; they also incur the costs and physical intrusion of those stations. With the emergence of smartphone GPS tracking and booking facilities, operators have been able to offer floating, or "dockless" bike sharing in which bikes are simply introduced into an area and secured using an internal lock. Two Chinese firms, *Ofo* and *Mobike*, have dominated the market since 2014. Such schemes offer greater flexibility, but as yet there is little information on their impact, apart from circumstantial evidence that they have reduced car use for journeys under 5km in Beijing and Shanghai. More recently, there has been serious concern over their misuse, with examples of bikes being left in piles at the roadside. While the lockable hubs in principle avoid bikes being left

in geo-fenced areas, vandals have found that the hub locks are easily removable. In Manchester, *Mobike* has recently withdrawn its service because of the rate of losses through vandalism and theft.

Ride sourcing Ride sourcing provides an alternative to the conventional taxi, by connecting private drivers with customers through a matching service using GPS-enabled smartphones. The largest operator, *Uber*, has been in operation since 2009, but has expanded rapidly since 2012. Operating companies, such as *Uber* and *Lyft*, are often referred to as Transportation Network Companies (TNCs). Since they treat their usage data as commercially confidential, it is difficult to obtain evidence on their impact. However, a recent independent study in the US has indicated that 60% of TNC users do so in preference to public transport, walking or cycling, with most of the remainder transferring from conventional taxis. TNCs only appear to be used in preference to a private car to avoid parking costs or drinking and driving (Schaller, 2018). As a result, Schaller estimates, TNC services add 2.8 veh-km for every vehicle-km of private car use removed, and have added 976m miles of driving to New York City's streets since 2013. A further study by Jin et al (2018) hints at similar concerns.

Demand-responsive micro-transit: taxi-based Since 2014, TNCs have introduced shared ride-sourcing operations, such as *UberPOOL* and *Lyft Line*, in which users share rides for a lower fee, but are then more constrained as to the journeys that they make. One operator, *Lyft*, plans to have 50% of rides being shared by 2022. There is even less information on the performance of such services, and a recent paper indicates the challenges in obtaining such information (Mohamed et al, 2018). However, Schaller notes that shared rides would still add to traffic because most journeys replace ones by public transport, walking or cycling. He estimates that *Lyft's* goal of 50% sharing would still produce 2.2 veh-km for every private vehicle-km removed from the network (Schaller, 2018). The International Transport Forum finds that very high levels of sharing and abandonment of personal car use are necessary to avoid rises in traffic levels (ITF, 2015).

Demand-responsive micro-transit: bus-based In response to the growth of TNCs, public transport operators have recently introduced new generation demand-responsive services using minibuses which offer a higher standard of passenger comfort and facilities, can be booked through GPS-enabled smartphones, and are available on fixed routes and flexibly within a defined area. These 'micro-transit' services, such as *ArrivaClick*, *Slide* and *Chariot*, are designed to plug the gap where mainstream public transport is not suitable. Since the earliest schemes only emerged in 2017, there is as yet no evidence on their performance and whether they are commercially more viable than previous incarnations of demand-responsive transport.

Mobility as a Service Mobility as a Service (MaaS) is defined by its designers as "the integration of various forms of transport services into a single mobility service accessible on demand". It offers a single platform and payment system including journey planning, real-time operational information, GPS-based tracking and integrated ticketing. The first system was introduced in Helsinki in 2017. Users can choose between three options: the all-inclusive service for €499/month covering all services including public transport, taxis, car sharing and bike sharing; unlimited bus travel, short city bike rides and reduced taxi fares for €49/month; and a pay-per-ride option that enables users to test the MaaS service. Currently, the MaaS service for Helsinki has 45,000 users with 5,100 paying monthly fees (ELTIS, 2018). Hoadley (2017) notes that the claim that MaaS can make people give up the car "does not just rely on the presence of a MaaS platform in a city or region, but more importantly on the availability of alternative transport modes (public transport, taxi, etc) and their effective combination". A recent trial in Manchester suggested that 26% of participants were more willing to use public transport, and 21% to walk and cycle, after using MaaS (LTT, 2018).

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3. The York case study

York is a city of 210,000 population 300km north of London. It has a 2000 year history, with the city centre still surrounded by its mediaeval walls, and an inner city road network constrained by protected buildings and vistas. It is a regional employment and retail centre, focused both on the city centre and on three late 20th century outer suburban retail centres. It is a major higher education centre, with two universities and 25,000 students. It is also a major tourist attraction, with some 7m visitors a year. While largely free-standing, it is 40km from Leeds, the major administrative centre of Yorkshire, and has excellent rail links to much of the rest of the country. Since 1996 the City of York Council has been a unitary authority, with direct responsibility for planning, employment, transport and the environment.

In common with the rest of England outside London, many of its bus services are run by commercial operators, with the Council able to subsidise socially needed services. However, the Council franchises six park and ride services and the University of York franchises its principal bus access route, resulting in around half of all bus patronage being on services where service standards are specified by an organisation other than the service operator. The Council has a Quality Bus Partnership with the six bus operators, which coordinates routes, fares, joint ticketing and standards.

From 2001, all local transport authorities in England were required to produce Local Transport Plans (LTPs), covering a five year period within a 20 year horizon. These formed the basis on which national government awarded funding to local authorities to finance transport investment and operations, and by the third round of LTPs the government offered considerable flexibility in the way in which such funding could be applied (May, 2013).

York's third LTP was published in 2011 and covered the period from 2011 to 2016, while looking ahead to 2031 (CYC, 2011). It reviewed York's successes, with an extensive foot street network in the centre, one of the highest modal shares for cycling in the country, and the country's largest park and ride network. It identified the principal problems as the constraints imposed by the mediaeval road network and the lack of crossings of the rivers, rail lines and green corridors; congestion on the single carriageway sections of the outer ring road, radial routes and the inner ring road around the city walls; high levels of car commuting into the city, particularly from the east; and serious air pollution. It already anticipated the need for growth, and the implications of growth for increased congestion and pollution. Its vision was to "enable everyone to undertake their activities in the most sustainable way and to have a transport system that:

- has people walking, cycling and using public transport more;
- makes York easier to get around with reliable and sustainable links within its own area, to adjacent areas and cities and the rest of the UK;
- enables people to travel in safety, comfort and security, whatever form of transport they use;
- provides equal access to opportunities for employment, education, training, good health and leisure for all, and
- addresses the transport-related climate change and local air quality issues in York."

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Its strategy to achieve this vision involved, *inter alia*, providing quality alternatives to the car to provide more choice and enable more trips to be undertaken by sustainable means, and encouraging behavioural change to maximise the use of walking, cycling and public transport. It confirmed the hierarchy of users introduced in its first LTP, which places pedestrians and those with mobility handicaps first, followed by cyclists, public transport users, commercial vehicles and lastly car users. Among public transport improvements it envisaged introducing more bus priority measures, improved bus stops, interchanges and real-time information, smart multi-operator tickets, hybrid fleets and expanded park and ride services in the period to 2016.

Performance indicators and targets were expressed in terms of flows and levels of access rather than modal shares, which makes comparison with other cities difficult, but modal shares for the journey to work from the 2011 census for York and comparable historic cities are shown in Table 1. These indicate that York had the highest sustainable mode share (at 43%), but that it was its much higher bicycle mode share which distinguished it. However, even its mode share statistics do not compare well with many continental European cities. For example, Freiburg in Germany, with a similar population to York, recorded a sustainable mode share of 79%, with 29% of journeys on foot and 34% by bicycle, in 2016 (EPOMM, 2018).

Table 1: Method of travel to work for selected historic cities: 2011 (%)

City	Bus	Rail	Car[1]	Bicycle	Foot	Other
Bath[2]	7	4	66	3	19	1
Chester[2]	4	2	79	3	11	1
Lancaster	6	2	70	4	16	1
Lincoln	6	1	66	6	20	1
Worcester	5	2	71	4	17	1
York	**8**	**3**	**57**	**12**	**19**	**1**

1: includes motorcycle and van
2: includes a wider rural hinterland
Source: 2011 census

In 2011 the government announced that it would no longer require local authorities to submit LTPs, instead leaving them to decide when they needed to do so; subsequently it has substantially reduced the funding available, with much of it being awarded competitively on a modal basis (May, 2013, Rutherford, 2018). The City of York Council now intends to develop a new LTP in 2019, and the case study (May and Marsden, 2018) was produced in conjunction with York Civic Trust as an input to that process. The City of York Council has recently submitted its Local Plan for the period to 2031 (CYC, 2018), which envisages the provision of 15,000 new homes and 10,000 new jobs, with development focused on ten major sites; three adjacent to the city centre and seven close to or outside the outer ring road.

In the case study (May and Marsden, 2018) we reviewed further analyses of the performance of the transport system. Figure 1 summarises a 2014 analysis of gaps in public transport provision (SDG, 2014), in which need, estimated from socio-economic data, is compared with provision. It shows a pattern of deficiencies in coverage in a ring roughly half way between the inner and outer ring roads, many of which are low income residential areas. Further analysis suggests that the principal problems are low frequency and indirect services. A report by the York Quality Bus Partnership, involving the council and the operators (YQBP, 2015) reviewed the pattern of delays to bus services. It identified 32 locations with significant delays, of which seven primarily involved boarding delays (typically at schools, but also the university) and 25 were caused by traffic, principally on the main radial routes and the inner ring road.

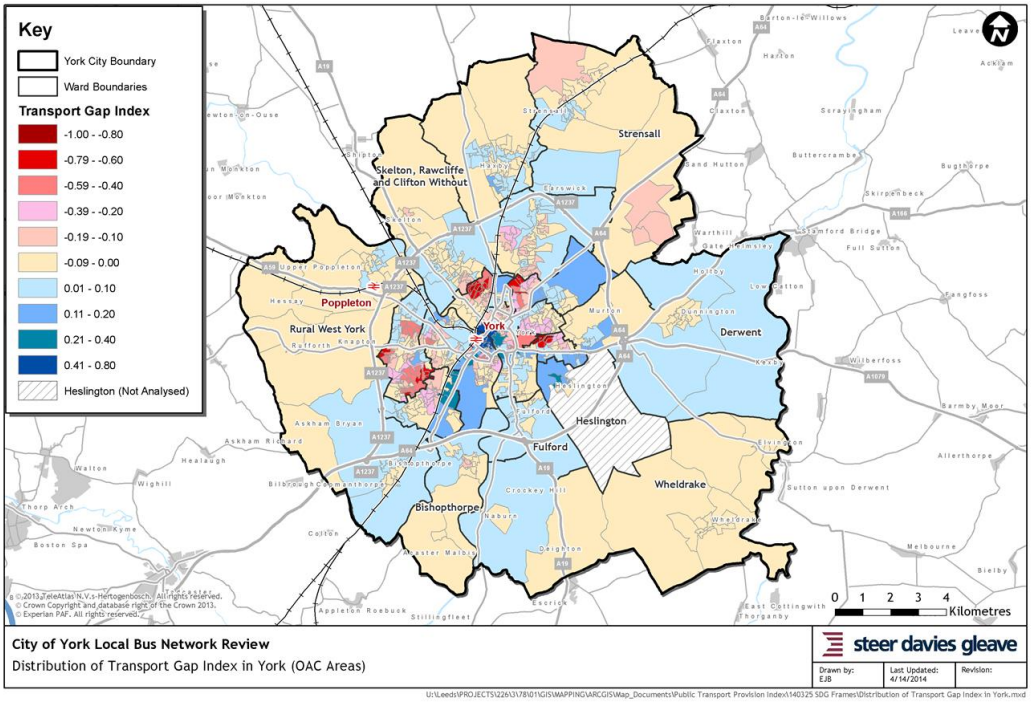

Figure 1: Public transport gap analysis for York (SDG, 2014)

Surveys elsewhere also point to factors which will affect York's public transport services. A recent survey of over 8000 people by Leeds City Council asked the public what they most wanted from the transport system **(**LCC, 2017). Schemes to improve bus journey times were rated important by 66% of respondents. Specifically on bus, the top five improvements mentioned by respondents in an open text response were 1) more reliable bus services; 2) cheaper services; 3) more frequent services; 4) more bus routes and 5) improved priority for buses on roads. Recent research suggests that those most in need of public transport may not contribute to such surveys or make their needs known. Low income households without cars face limitations in the spatial mismatch between housing and employment, temporal mismatches between employment and caring schedules and transport timetables, and resource constraints aggravated by high fares (Crisp et al, 2017). Around 7% of households have cars but are materially deprived and hence restricted in their ability to travel (Mattioli, 2017). Underlying national trends suggest that reduced budgets are leading to fares increases and service reductions, resulting in bus journeys per capita falling by over 10% in the major conurbations over an eight year period to 2016/17 (DfT, 2017a). However, York has managed to buck these trends, with some services increasing in frequency, some targeted fares reductions, and an increase in ridership of 12% in the four years to 2016/17. As a result, York currently has high passenger satisfaction and the tenth highest ridership level (in trips per capita) outside London.

However, analysis conducted by City of York Council for its Local Plan indicates the extent to which the problems of congestion might be aggravated by the planned new developments, if no further action is taken. Figure 2 illustrates the projections for the evening peak, with most of the network inside the outer ring road operating at under 30km/h, and substantial sections at under 15km/h (CYC, 2017).

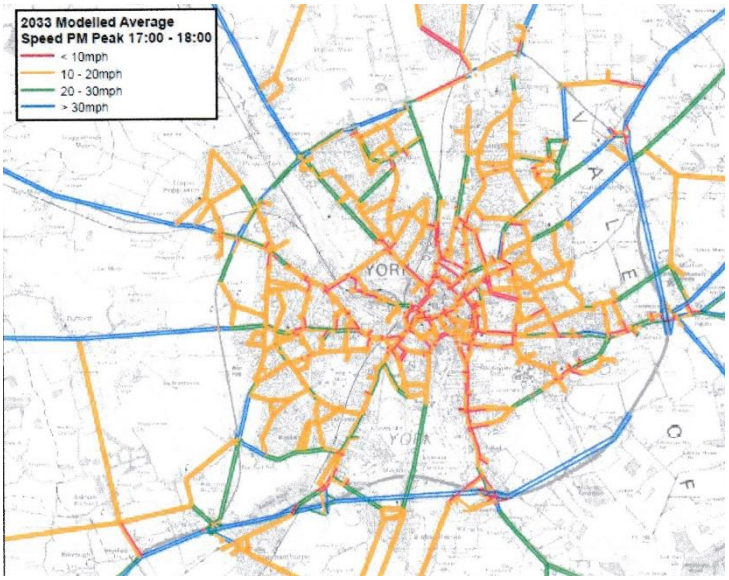

Figure 2 Predicted evening peak speeds with new development in 2033 (CYC, 2017)

These analyses suggest that the principal challenges which a public transport strategy for York needs to address are:

- a relatively low mode share for sustainable modes (when compared with continental European cities)
- incomplete spatial coverage of public transport services
- incomplete temporal coverage (particularly evenings and Sundays)
- need to provide for new developments
- significant delays for existing buses
- an underlying desire among users for better services
- financial pressures and
- governance barriers.

It appears likely that other medium sized cities, where public transport is predominantly bus-based, will face similar challenges. In the following section we consider the potential of existing and new mobility services to address them.

4. The potential applications of new mobility services

The starting point in considering a public transport strategy must be to assess the future contribution of the public transport services which are currently available. Having done this, we then consider in turn each of the new mobility services which is now on offer, and assess its ability to complement current provision. We summarise the potential of each of these interventions to address the challenges listed above and suggest an approach to developing an integrated strategy.

Improving conventional services

Extended bus services It is of course possible to expand the coverage of conventional bus services, which should in turn increase mode share. The York case study and the eight challenges suggest that this could be done by increasing frequencies, making services more direct, introducing new routes, extending services to the

evenings and weekends, and providing conventional services to new developments. However, many of the journeys involved, particularly when extending the time of operation, are likely to be of relatively low demand and thus to require subsidy. Under the deregulated environment operating in the UK this would require the local authority to seek subsidised tenders and have funding in place for their operation. The financing of services to new developments would depend on any requirements placed on the developer and any time limits on them.

Improved infrastructure for buses Local authorities are able to influence the conditions within which buses operate by providing bus stops and interchanges, by giving buses priority on critical links, at junctions and at bus stops, and more widely by managing parking and introducing measures to control car use (Lautso et al, 2004; May et al, 2005). While the easiest measures will already have been adopted, further application should help reduce delays, increase the perception of service quality, and hence increase mode share. The principal barrier to providing greater priority over other traffic is typically public acceptability.

Improved information Real time information for public transport now extends beyond the bus stop to include information within the vehicle and through mobility apps and journey planners on mobile phones. In the UK the Bus Services Act (DfT, 2017b) requires the introduction of audio and visual information within buses which will improve the usability of the system for tourists, occasional users and those with hearing and visual impairments. A key issue for many local authorities is whether the public transport information on mobile phones is integrated with that provided at bus stops and in vehicles. There is some evidence that improved information increases perceptions of service quality, and hence mode share, but the links appear to be relatively weak.

Alternative payment methods There has been a major shift to simpler payment methods, with parallel developments in the use of smart cards, smart phone apps and contactless payments. The shift to mobile and contactless payment could be particularly important to the efficiency of bus services. In a research study, *First* found that boarding time with flash pass mobile ticketing was 75% faster than with cash payments. Such an approach would help, for example, to overcome serious delays at the seven locations in York where boarding is the principal cause. However, where there are several competing bus operators, as in many UK cities, there is still a need to provide a common ticketing system. There is evidence that simpler payment systems enhance the perception of service quality, increase mode share and, to a lesser extent, increase revenue.

New mobility services

Car sharing Station-based car sharing is already widely used, but could be extended further to provide an alternative to private car use in suburban hubs and in new developments where it could encourage new residents not to rely on private cars. Floating car sharing offers a similar potential, but without the constraints of fixed pickup points. In this way it offers better spatial coverage. Conversely, it may be less appropriate in new developments, since it does not offer a fixed provision. Both are particularly suited to evening and weekend use when conventional public transport is less cost-effective, but both rely on a commercial operator running the scheme profitably.

Bike sharing A docked bike share scheme is inevitably limited in its spatial coverage, but offers a 24 hour service, and can readily be introduced into new developments. There is increasing evidence that it can attract patronage from the private car, and that it offers a cost-effective way of doing so. Floating bike share schemes remove the spatial constraints, though this may once again make them less appropriate for new developments. They are likely to be an even more cost-effective way of reducing car use but, given present experience, may well be difficult to manage to avoid vandalism and street clutter.

Ride sourcing Ride sourcing as currently operated extracts patronage principally from sustainable modes, and adds to private vehicle traffic. It has also proven difficult for local authorities to negotiate with TNCs to

achieve services which are more in the public interest. However, if that governance challenge could be overcome, ride sourcing could offer a particularly cost-effective way of extending temporal coverage and might also assist with non-central journeys and those from new developments.

Demand responsive micro-transit Taxi-based micro-transit appears likely to offer the same threats and opportunities as ride sourcing. To a limited extent it may be more effective in attracting patronage from the car, but is still likely to increase traffic levels. If governance problems can be overcome it may be more effective at increasing spatial coverage than conventional ride sourcing. Bus-based micro-transit is in the very early stages of development, but in many ways appears to offer the greatest potential for extending coverage spatially and temporally. As such it may be particularly appropriate in new suburban developments. However, it seems likely that such extended services would require some subsidy from local government.

Mobility as a Service MaaS offers a more integrated mobility system in which information, costs and payments are provided seamlessly for the range of services available in a city. It thus offers the potential to act as an umbrella for all of the above new mobility services. On its own it does not extend the coverage of the public transport service, but early evidence suggests that it might help further to improve the perceived quality of that service, increase mode share and, to a lesser extent, increase revenue. However, the wide range of service providers to be included may represent a significant challenge.

In Table 2, we assess the potential of each of these policy interventions to respond to the challenges listed in Section 3. New mobility services are shown in italic. Conventional policies offer modest contributions, but include the only ways of achieving reductions in delay to buses. Between them the new mobility services offer ways of further improving spatial and temporal coverage and of increasing sustainable mode share. MaaS and to a lesser extent demand responsive bus-based services are the most likely to enhance perceptions of quality. Many of the new mobility services avoid financial barriers by being externally funded, but MaaS and bike sharing offer the greatest potential to reduce public sector costs. The main threats arise from TNCs' services, which threaten to increase congestion and reduce sustainable mode share. While they have the potential to extend service coverage, they therefore need to be managed carefully.

Table 2: Contribution of policy interventions to the eight challenges

Policy	Mode share	Spatial coverage	Temporal coverage	New development	Delays	Better services	Finance	Governance
Extended bus services	√	√√	√	√√			**xx**	**x**
Improved infrastructure	√√				√√	√√	**xx**	
Improved information	√					√		**x**
Alternative payment methods	√√					√√	√	**x**
Car sharing station based		√	√√	√√				**x**
Car sharing floating		√√	√√	√				**xx**
Bike share docked	√√	√	√√	√√			√	**x**
Bike share floating	√√	√√	√√	√			√√	**xx**
Ride sourcing	**xx**	√	√√√	√	**xx**			**xxx**
Demand responsive taxi-based	**x**	√√	√√	√	**xx**			**xxx**
Demand responsive bus-based	√	√√√	√√√	√√√		√	**x**	**x**
Mobility as a Service	√√					√√	√	**xx**

In formulating its governance strategy, York first needs to determine its transport strategy. As noted in Section 3, the strategy needs to focus both on meeting unmet needs and on providing effective alternatives to the car. It is clear from Table 2 that there is no one best solution among the new mobility services on offer. We suggest that the strategy is best developed by considering each type of movement in the city separately by orientation, distance and time of day, determining the current modal mix and unmet current and future demand, assessing which of the current and new mobility services offer the best alternatives to the private car for each movement type, and taking steps to promote those services and provide the necessary infrastructure support, while imposing controls where necessary on the levels of car use. Such an approach would allow the city to assess the likely requirement for sustainable modes without and with demand management, the need for complementarity between those modes, and the cost-effectiveness of any interventions needed. This approach could, in the York case study, be applied to the new residential developments proposed in the Local Plan, and would offer a cost-effective and clearly argued alternative to the predictions of extreme congestion typified by Figure 2. It would also provide a way of tackling the

gaps in provision suggested in Figure 1, and those which are becoming apparent in addressing the city centre's night time economy.

5. **Governance**

It is clear from the analysis in Table 2 that an effective strategy is likely to involve a number of policy interventions, many of them from the range of new mobility services, which are typically offered and managed by third parties. Moreover, there are some new mobility services, and particularly those offered by TNCs, which could have deleterious effects and need to be carefully regulated. This is a challenge which most cities face (Marsden and Reardon, 2018), but in some ways UK cities, which have had to work for many years with complex governance structures, may be better placed to respond.

Cities will need to ensure that the new providers of transport are carefully integrated within the existing system of provision so that they are complementary to, rather than in competition with existing modes. This will be particularly critical given the limited ability of local government finances to cover any additional subsidy burdens. In doing so, cities will need to act as an intermediary between existing providers who are nervous of a loss of business, and the new providers (Docherty et al., 2017; Hensher, 2018). The expanded range of new providers will bring with them the promise of better service provision for lower or zero subsidy, but new technology does not wish away the fundamental economics of service provision, which implies that some communities, particularly but not exclusively in more peripheral areas, will be less well served and will continue to justify intervention on social equity grounds. It is only local government that is mandated to determine what is in the interests of all its citizens and what mix of solutions will best meet its objectives. Without a strong steer, the individual operators are as unlikely to deliver an integrated outcome as the existing mix of private sector providers have in previous decades. This begs two questions: what might the most appropriate governance structure be, and what power and resources can a city bring to bear to ensure that that governance structure is effective?

On governance, there is now useful European guidance on the broad question of institutional cooperation (POLIS and WYCA, 2016), as well as specific guidance related to new mobility services (Marsden and Reardon, 2018). Both stress the importance of identifying the full range of actors, agreeing on the overall objectives, ensuring that these objectives are aligned with those of individual partners, deciding on the most effective policy interventions and their timing, sharing responsibilities while providing leadership, allocating resources appropriately, ensuring transparency through the sharing of data, and rewarding success. It may be that the best model for achieving this in a city like York is to expand its Quality Bus Partnership to encompass the wider range of actors. A broader Quality Access Partnership could potentially be managed to ensure that the most cost-effective alternatives to the private car are offered in each of the corridors of movement identified in the strategy, that the resulting services complement rather than compete with one another, and that the limited financial support available is focused on the most cost-effective solutions. In this context the development of MaaS could well serve as an integrating facility.

Cities have a combination of hard powers and soft powers at their disposal (Nye, 1980). Looking first at hard powers, one of the critical means they have for influencing mode choice is the allocation of infrastructure for specific modes and for shared use. As the York case study showed (May and Marsden, 2018), more can still be done to provide priority in bus corridors and for cycling, and it will be appropriate to consider broadening that provision to cater for new demand responsive services and for bike sharing. Cities can reduce car use and improve bus stop operation through management of parking policy, which will need to evolve to management of the kerbside as it becomes more intensively used (ITF, 2018). This raises in turn the broader question of demand management, which will become increasingly important if sustainable modes are to be protected from congestion, but which requires significant political commitment. Many of these factors come together in planning for future growth. In setting out their strategic land-use plans, cities have the scope to ensure that new housing developments are implemented with appropriate priority and provision for sustainable modes, and with limitations on provision for the car. However, this requires politicians to be prepared to dictate their requirements to developers. One area in which hard powers

are currently uncertain relates to the regulatory environment. It is clear that cities will need to be able to determine where new mobility services would be disruptive, and to regulate to avoid such disruption. This will require a national commitment to a more effective regulatory environment, particularly for TNCs but also more generally for private sector operators of public services.

As regards soft powers, there are also several options. Cities offer a gateway to funding from national governments for pilots and demonstrations to help de-risk the implementation of potentially advantageous innovations. They can promote themselves as testbeds for new technologies. They are also important brokers with the major trip generators in the city including hospitals, universities and major employers in influencing the take-up of new services such as micro-transit and bike sharing. They can play a role as risk sharers, for example by integrating micro-transit with existing services. Finally, they can coordinate the monitoring and evaluation of the transport system, and hence demonstrate and reward the success of new policy interventions.

6. Conclusions and policy implications

The nature of public transport is changing rapidly with the development of new mobility services such as shared taxis, demand-responsive buses, shared cars and bikes, new approaches to charging for public transport and the emergence of Mobility as a Service (MaaS). Cities face two difficulties in incorporating such innovations into their Sustainable Urban Mobility Plans (SUMPs): there is still very limited information on their performance, and most are offered by third parties who are not in the public sector, and are not necessarily committed to the objectives of a city's SUMP. We assessed the potential of such innovations, the ways in which they might be harnessed, and the governance implications based initially on a case study of York, a free-standing historic city of 210,000 inhabitants in the north of England.

That case study highlights eight challenges which a future public transport strategy needs to tackle if it is to provide an effective alternative to the private car: it needs to increase the sustainable mode share, enhance both spatial and temporal coverage, provide effectively for new urban developments, reduce the delays experienced by public transport, increase the perceived quality of the overall service offered, reduce the public subsidy required and ensure effective governance.

In terms of those challenges, we find that bus-based demand-responsive micro-transit, floating bike sharing and to a lesser extent car sharing offer the greatest potential to increase service coverage. The services offered by Transportation Network Companies also have the potential to extend service coverage, but risk reducing sustainable mode share and increasing delay. Reductions in delay are most likely to be stimulated by demand management and conventional infrastructure improvements. Increases in perceived quality and in sustainable mode share might best be stimulated by bus-based micro-transit, Mobility as a Service and, for mode share, bike sharing. Many of the new mobility services avoid financial barriers by being externally funded, while Mobility as a Service and bike sharing could help to reduce the requirement for public subsidy.

It is clear from this assessment that a combination of sustainable modes will be needed if unmet needs are to be provided for and car use reduced. Thus the city's approach needs to be interventionist and proactive rather than *laissez faire*. We propose a spatial and temporal corridor-based approach in which current and future movement patterns are assessed to identify the appropriate mix of mobility services, and the network enhancements which are needed for each. While the analysis of these requirements should be led by the local authority, their funding and implementation need to be coordinated by all the actors involved, including the providers of new mobility services. This requires a new approach to governance.

We envisage a Quality Access Partnership, including all existing operators and the providers of micro-transit services, car and bike sharing and TNCs, as offering an appropriate governance model. The introduction of MaaS could provide the catalyst for integrating this full range of providers. Within this model, the city will need to provide

professional leadership, and to make effective use of the hard and soft powers at its disposal. Among hard powers the most important are likely to be road space allocation and demand management, and the imposition of sustainable access principles on new developments. Among soft powers the city should continue to offer itself as a testbed for innovation, seek government funding for such innovations, and provide the resources to evaluate them to demonstrate and reward success. However, to perform effectively, cities will need a stronger regulatory environment in which to manage new mobility services, which has to be provided by national government.

Acknowledgements

We are grateful to the York Civic Trust for initiating the case study on which this paper is based, to the York Bus Forum for inviting us to present an initial outline of the case study, and to colleagues at the Vienna workshop at which the earlier version of this paper was presented. We particularly acknowledge the helpful and critical comments of Andrew Bradley and Julian Ridge of City of York Council. We emphasise, however, that the views expressed, and any omissions and errors, are our own, and should not be taken to reflect the policies of the City of York Council, York Civic Trust or York Bus Forum.

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