Moving Cities:
The future of urban travel

Edited by:
Glaister & Box
December 2014

RAC Foundation

The Royal Automobile Club Foundation for Motoring Ltd is a transport policy and research organisation which explores the economic, mobility, safety and environmental issues relating to roads and their users. The Foundation publishes independent and authoritative research with which it promotes informed debate and advocates policy in the interest of the responsible motorist.

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His work over the past decade has focused on two related fields of endeavour: the access and movement aspects of complex urban development projects; and the detailed design of multi-functional, accessible and safe streets and spaces in urban centres and around stations. John is a streets design advisor to several UK local authorities, a trustee of Living Streets, and author of the monthly 'Street Talk' column in Local Transport Today.

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Ford Motor Company, a global automotive industry leader based in Dearborn, Michigan in the United States, manufactures and distributes automobiles across six continents. With around 166,000 employees and 77 office and plant locations around the world, Ford Motor Company is focused on creating a strong business that builds great products that contribute to a better world. The company also provides financial services through Ford Motor Credit Company.

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John Miles is a fellow of Emmanuel College, Cambridge and is Chair of the Automotive Council's Working Group on Intelligent Mobility. Formerly a Main Board Director at Arup Group, he took up his role at Cambridge University in January 2012 with the intention of exploring affordable, low carbon, energy technologies and business models.

Since his appointment at Cambridge, John has been particularly active in the field of low carbon transport. He has been a prime contributor to the Mitsui-Arup electric bus fleet demonstration programme in Milton Keynes, in which the UK's first demonstration of a bus service using wireless charging has been launched. He is also Programme Architect for LUTZ (low carbon urban transport zone), an industry / local authority collaboration programme which has been set-up to explore the potential for using Low-Speed Autonomous

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Imperial College London

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Since his previous role of Director of Fares & Ticketing Shashi has focused on improving the performance of ticketing systems, which are now at a record high; on reducing the cost of ticketing services, achieved through an early termination of the Prestige Ticketing Services Contract; on extending the reach of Oyster on London's national rail and river services; and on developing the next generation of fare collection solutions for London.

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Dr Scott Le Vine is dually-appointed as an Assistant Professor (Urban Planning) at SUNY New Paltz (NY, USA) and a Research Associate in the Centre for Transport Studies, Imperial College London. He serves on three standing committees of the USA's National Academy of Sciences' Transportation Research Board. He is a trustee of the charity Carplus.

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Christian Wolmar is a writer and broadcaster specialising in transport and has written a series of books on railways including 'On the Wrong Line, how ideology and incompetence wrecked Britain's railways', 'Fire & Steam, a new history of Britain's railways', and most recently 'To the edge of the world, the history of the Transsiberian railway'. He has also co-edited a book on financing urban transport, Urban Access for the 21st Century published by Routledge. He has written a column for Rail magazine since 1995 and frequently contributes to national newspapers such as The Guardian and The Times. Christian was a board member of Cycling England until its abolition in the spring of 2011 and was a founding trustee of the Railway Children charity.

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Disclaimer

This collection of essays has been prepared for the RAC Foundation by the authors and organisations listed. The report content reflects the views of the authors and not necessarily those of the RAC Foundation. Any errors or omissions are the authors' responsibility.

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Foreword

Since its inception, the RAC Foundation has worked to support the interests of the responsible motorist. Taking an evidence-based approach, the Foundation is well known for commissioning and publishing reports that have focused on the four key areas of transport policy affecting the motorist: safety, the environment, mobility and economics.

In this collection of essays we concentrate on the future of urban travel. We have asked our contributors to help us understand what the prospects are for personal and public transport in an urban environment, and what challenges and opportunities are already discernible.

The scope of the essays is broad, encompassing demography; multimodal requirements; health considerations; regulation and governance; changing work behaviours; the changing economic circumstances of young adults; funding for roads; local versus national control of transport; the impact of new automotive technologies and infrastructure on emissions, congestion and vehicle ownership; and – with the availability of autonomous vehicles no longer a distant prospect – the issue of human interface with vehicle control itself.

Despite its breadth, this is clearly not an exhaustive list of topics relevant to the theme. Our objective is to stimulate further discussion amongst decision-makers as we begin to take stock of the challenges and opportunities facing us. Future urban travel is a theme that the Foundation intends to return to regularly with the aim of helping to inform policy development. We hope that you find the essays both enjoyable and informative.

Joe Greenwell CBE DL

Chairman, RAC Foundation

1. RAC Foundation viewpoint

1 Introduction

For many reasons – most of which are obvious – trying to predict the future, and then plan for it, is an inexact science. If any of us knew what next week, next month, next year held in store then we'd be rich. But we're not.

Equally, precisely because of that uncertainty, futurology is something everyone is happy to have a go at. Why not try some crystal-ball gazing? After all, if you're wrong then you're in good company.

Yet the inherent difficulties associated with looking forward do not mean that it is a wasted exercise. Certainly those in authority cannot sit back and resign themselves to fate. Not only can policymakers glean clues from history about what might be to come, but they also have the potential to shape the future through the laws they make and the money they spend.

So where does the future lie when it comes to transport?

The RAC Foundation asked twelve authors to give their views on how the shape of travel in our urban areas might look in the years ahead.

Authors with a wide range of expertise and from diverse philosophical backgrounds were commissioned to contribute their thoughts. Each was offered the same general context, and within that context a distinct subject area. We have concentrated mainly on the British urban situation, though much of the material will apply equally to towns in the rest of the developed world.

The essays have been subject to copy editing, but are otherwise published as we received them. There has been no editorial attempt to impose a theme. Each paper is published in this collection under the name of its author. No author had sight of the other authors' papers before writing their own contribution, except for Christian Wolmar, whom we invited to take an independent overview.

This introduction sets out issues identified by the RAC Foundation as important to the discussion. It is stimulated by what the contributors have said but it does not represent a systematic attempt to summarise them.

As we had expected, a wide range of views emerges from the collection, not all of them consistent. For instance some authors argue that urban mobility will continue to be expressed principally by the privately owned vehicle, whereas others insist on the necessity of centrally directed local planning to ensure that this is not the case.

2 Increasing urbanisation

There is common ground among the majority of contributors that it is impossible to predict the future with precision. However, it is also a matter of agreement that urban populations are likely to continue to increase, whilst the total physical area in which they will do so will not – in other words, average urban densities will rise.

People and goods will continue to demand mobility, both within and between urban centres. None of our authors has suggested that the ongoing revolution in communications technology will do away with – or even significantly reduce – the need for us to move around for work, education, shopping and, increasingly, leisure. We will still need food, consumer goods and services to reach our homes and places of work (and the forecast growth in population and employment will mean there will be more of them).

Heavy rail will play a role in this, but its inherent inflexibility and network sparseness imply that it will specialise in what it handles best: intercity movement and concentrated, long-distance commuter flows, particularly in London and the South East.

As it stands, travel as a car or van driver or passenger is more common than by all other modes – even in London, which has such good public transport services, this accounts for 51% of personal mileage (and much more in the rest of Britain). This, then, makes it more common than walking, cycling, and bus, underground and rail travel put together.

We are surprised that few of our authors gave close attention to walking. Even where it does not account for the whole of a trip (and it often does), it will be essential at one end or the other – and probably both. Individuals who are unable to walk far suffer significant loss of mobility. The health messages in relation to the advantages of cycling are important, but so they are in relation to walking. We note that some of the proposals for new vehicles to enhance mobility in the future (e.g., driverless 'pods') are in locations, and over the kinds of distances, that healthy people can and do walk. Even cycling is, to a degree, competitive with walking – as well as all motorised modes for short journeys and medium-length journeys without baggage.

3 The unchanging fundamentals

There has been gradual evolution since the 1960s, the biggest change being the growth of personal car ownership. But the fundamental questions have stayed the same over time, and will remain unchanged into the future:

- **Severe competition for space**: in town centres there simply is not enough room for everybody to have their own car. Well-used mass transport modes are essential in order to shift enough people over (or under) the available land. But note that the situation can be quite different in the peripheries.

- **Governance**: who makes decisions, and by what mechanism. Urban mobility will always have a strong component of public realm. Arguably – alongside water supply, clean air, waste disposal and civic order – mobility is the prime business of urban government.

- **The money**: how to get adequate funds for (a) maintenance of facilities – whatever we have, it will have to be properly maintained and renewed; (b) revenue subsidy for unprofitable public services; and (c) capital investment. And who pays?

- **Regulation** in the public interest for safety, and of the terms of competition within and between modes.

Demographic change and technical innovation will not change these fundamentals.

The need for mobility of goods and people seems to be basic. Indeed, it is arguably the short travel distances and relative ease of meeting people within cities that create their productivity, thus justifying their existence. Otherwise we would live uniformly spread throughout the land. It seems likely that the demand for mobility will remain despite the increasing ease of communication. Indeed, one view is that historical improvements in communications technologies have tended to generate more travel, not less.

So as urban populations grow, there will be more demand for the ability to have access to one another, and also to goods and services.

Larger cities tend to have less road space per head of population. Consequently they tend to be more reliant on space-efficient mass modes of transport. By the same token, the higher density of patronage makes them more commercially viable. At the other end of the spectrum, attempting to run high-capacity public services in lower-density areas will always be a commercial struggle, making personal transport relatively more viable there.

One thing that has made a real difference, and will continue to do so, has been the spectacular innovation in automotive manufacture, reducing the cost of vehicles available to ordinary people whilst improving their quality. In the fog of the controversies surrounding transport policy it is easy to forget that – in spite of all the disadvantages – the availability of relatively cheap motor vehicles to ordinary people on middle and lower incomes has been a spectacular source of improved mobility. Overall, it has been a major facilitator of enhanced quality of life and economic well-being.

4 Governance

A number of authors noted that a crucial issue when considering the nature of urban mobility in future is governance.

Will we retain the same highly centralist system of local government finance, or, as seems increasingly likely, will control of spending and the sources of funds revert towards fully devolved local or regional government – as it is almost everywhere in the developed world?

There seems to be a general consensus in favour of local communities taking responsibility for local transport planning and policies. That said, we note that, paradoxically, some authors seek a centralist requirement that the plan should adopt the premise that private car use should be reduced, rather than letting local communities decide on this matter for themselves. There are arguments in favour of this policy, but left to their own decisions many local communities would give emphasis to the private car – and the more so if they had to pay through their local taxes for their public transport investment and operating subsidies. This old debate concerns the balance between true localism and central control in the national interest.

It is plain that in Britain we have a number of problems relating to lack of transparency and ill-coordinated responsibilities. The smaller urban areas are variously dealt with by local transport bodies, local enterprise partnerships and local authorities. At the other end of the scale, London enjoys the relative coherence of the elected Mayor, the Greater London Authority, and Transport for London. Yet even in the capital, there remain the 32 boroughs and the City of London as highway authorities, and a commuter railway under the control of the national Department for Transport. And, as the London Olympics so vividly illustrated, there is a need to secure the co-ordination and co-operation between Transport for London, Network Rail, the Metropolitan Police, the City of London Police, the British Transport Police and the other emergency services.

Will the new technologies encourage the provision of services which are more closely matched to specific local needs? And will that in turn encourage more open, city-level government in place of regional government?

5 Pricing and charging

The advent of the electronic technologies does have a number of important implications for the funding, administration and regulation of urban mobility. Road traffic movements and parking events can also be monitored more closely.

It has become easier to record events such as the purchase of the authority to travel. The days of cash handling and the paper ticket are coming to an end. Apart from the cost savings and avoidance of petty fraud that come with this development, it has become easier to identify the costs of providing for what each individual chooses to do. Records can be kept which improve the accuracy of revenue attribution between several operators. Rates of charge can easily be varied by time of day, location and mode. It is now technically possible to levy charges for road use as well as for parking, taxis and public transport.

The twin implications of this are that the authorities can manage the time, place and mode of demand for their services at a finer grain, and that revenues can be related more closely to both willingness to pay and costs. In effect, they are receiving data from a continuous census of transport usage. This gives new dimensions to policy on patterns of financial support. It is easy to underestimate the importance of these considerations, but the magnitudes of the current cross-subsidies between services, and of the revenues that could be available from charging road users, illustrate the point.

Additionally, different individuals can be charged at different rates, giving the opportunity to structure travel concessions in a way that more accurately achieves policy objectives.

In particular, electronic charging systems make it easier to use pricing to manage demand by time of day, on both public transport and roads. Manifestly, most urban systems have spare capacity for long periods during the weekly cycle. And the industries, electronic communications and flexible lifestyles of the modern world are all conspiring to show that the hitherto inflexible nine-to-five, Monday-to-Friday working pattern is no longer inviolate. In the urban environment, where competition for space is so fierce, it is inefficient for us all to attempt to use that space all at once. There are many demonstrations of how varying rates of charge over time can help to co-ordinate our demands and spread the load.

There is much more that could be done, and the emergent technologies offer the means to do it.

Some authors see this, together with a less traditional public sector attitude to charging, leading to mobility as a subscription service – in a manner rather similar to the present-day provision of mobile telephone services. They argue that one might purchase – and trade – 'mobility minutes'. This could include services such as capacity slots on the roads and reserved car parking places.

By creating markets where none presently exist, these developments could greatly increase the efficiency with which we use the space that is available for mobility.

6 Monopoly and competition

The ability to locate one another, to communicate cheaply, and to express individual requirements in real time is beginning to blur the traditional distinctions between methods of delivering personal mobility.

Lift sharing, car clubs and the sharing of residential parking spaces are not yet common, but they are now feasible. Maybe improved communications technology and the entry of large vehicle manufacturers into the field of car clubs will provide the impetus for their proliferation that seems to have been lacking thus far. But the rate at which they develop will depend crucially on public authorities granting the facilities needed – such as kerb space – and the incentives that individuals have to take them up.

In part, the magnitudes of these incentives depend upon the scale of the artificial distortions enforced under the traditional regulatory systems. For example a Hackney carriage (the 'black cab') enjoys a monopoly, conferring a commercial advantage by virtue of its right to pick up passengers at will and straight from the street, whereas a private hire trip must be booked in advance. In return, a Hackney carriage has to conform with extra safety and other standards, and is legally obliged to charge no more than the amount shown on an approved meter.

As the 2014 dispute in London over the entry of the commercial product Uber illustrates, the powerful technologies now in the hands of private individuals make it easier to erode barriers created by statutory regulation or lack of information – arguably to the benefit of the consumer.

More generally, in urban transport as elsewhere, more cheap and timely information strengthens the forces of competition, with consequences for taxi and public transport services.

Yet rapidly developing technologies also create the opportunity for new monopolies to be established. If a particular piece of software is commercially successful, then competitors without access to the software, or to the data on which it relies, might find themselves at a disadvantage. Similarly, proprietary communications protocols can create barriers to competition, and this might may operate against the public interest. As urban transport systems become increasingly reliant on software, data and communications, these issues become more significant. Transport for London has illustrated the public benefit of making its data open data and allowing individuals freedom to develop a wide range of commercial applications.

Should public policy seek to force ‘transportation network companies’ to be open to competition, or should they be encouraged to coalesce in order to take advantage of the inherent technical economies of scale?

From the consumers’ point of view, an important determinant in the competition between public transport, car and self-driving car is the cost to the user of the in-vehicle time. The advent of wireless connectivity on public transport is reducing that cost relative to the conventional car.

If buses and taxis could do without their human drivers these modes would gain a further advantage through reduced operating costs.

A car that drives itself would tip the balance the other way. But this is some way off. In the meantime, the new communications technologies facilitate the replacement of an expensive, professional car driver by a part-time or amateur driver – whether by means of journey sharing or informal lift-giving – if the regulations permit it. This could make a positive difference, and quickly, to the cost and availability of taxi-like mobility.

7 Technology

The impact of changing technologies will continue to be ‘evolutionary rather than revolutionary’.

In heavy rail, new signalling technology is now being installed. This, the biggest innovation for decades, claims to offer increased throughput, more reliability and the potential for trains to drive themselves. The obstacles to its full adoption are (a) institutional resistance to removing the human driver; (b) the cost of re-equipping; and (c) the complexity of the historical layout, service patterns and platforms at terminal stations, all of which create conflicts and impose limits on the capacity of urban railways. Although this is a radical new technology which will improve services and reduce costs, it will take a long time for passengers to benefit. And we will end up with essentially the same kind of service from much the same, rather sparse, set of stations.

Much attention is presently being given to the prospect of the self-driving car. This is something of a diversion – at least for the next few years. Even if fully self-driving vehicles were to become universally available tomorrow, that would not in itself fundamentally remedy urban mobility problems.

Some people make claims that effective capacity on the roads would be greatly increased by the advent of the self-driving car. But these claims remain to be validated in the complexity of real, congested streets – especially during a long transitional period where conventional vehicles remain.

Certainly, by removing human error, automation will improve road safety. And to the extent that automation reduces collisions, it will indeed increase the effective capacity of congested networks – as a significant proportion of delays are collision-related.

The high safety margins that will be required of automated operation, together with the concerns that manufacturers have about liability for the consequences of any untoward incidents, may in practice militate against any increase in traffic capacity – particularly if pedestrians and others learn that they can safely assert dominance of the road.

If self-driving cars were widely available they would make personal mechanised travel available to people (e.g. children) who at present cannot or will not drive themselves, and will lower the cost of time spent in the vehicle for everyone. These are indeed benefits to consumers, but both trends will enable the car to compete more effectively against walking, cycling and public transport – which might cause problems for other aspects of urban mobility policy.

Meanwhile the accumulation of a succession of relatively small technical improvements is already transforming the ‘conventional’ private car: electronic stability control, autonomous emergency braking, route-finding, lane-keeping, automatic and adaptive speed control. Automation is undoubtedly helpful when it comes to emergency manoeuvres. Some features, such as proximity detection and self-parking, are of particular benefit to older drivers, who, as we know, will increase greatly in numbers.

The adoption of new electronic technology (including self-driving) is not the same thing as electrification of the power train. We can (and will) have the former without necessarily having the latter.

The technology of the conventional internal-combustion engine – individually and also in partnership with hybridisation or plug-in hybridisation – is improving rapidly. The low cost and convenience of these conventional technologies relative to pure electric vehicles means that the internal-combustion engine will not be eliminated for a long time yet.

Incidentally, these further technical improvements will also help with the air quality problems that have historically been caused by conventional engines in urban areas, and will thereby narrow the advantage that pure electric or hydrogen fuelled vehicles have on this count. This issue is a much more important one to resolve in the urban context than in the rural because that is where the exposure of people to transport-related air pollution is greatest.

The use of direct sunlight as an electrical source for urban vehicles is already developing. Whilst the availability of sunlight will make it more successful in some parts of the world than in the UK, these technologies can make a real difference to their energy consumption.

Flexibility in the use of fuels will be important: petrol, liquefied natural gas, compressed natural gas, hydrogen, electricity. So an important policy issue is the future levels of duty on these fuels. Presently, the economics of electric vehicles are severely distorted by the vast difference in tax rates between electricity and hydrocarbon fuels.

Traffic control systems are another area where there is scope for improvement over time. This is both a matter of the public authorities finding the funding – and the political will – to install more, and more up-to-date, equipment on the one hand, and the willingness of the administration to use that equipment more actively, in real time, from central control facilities on the other. Again, this is incremental: computerised traffic signals have been around for decades. But their current capabilities have not been fully exploited, and improved real-time information collection, software and training of human controllers all have more to offer.

There remains scope for extending the use of traffic control systems in allocating junction capacity more selectively and less wastefully. For instance, intelligent bus priority systems benefit bus passengers by regulating the service and also free up capacity for other users when it is not needed for buses. Pedestrian phases at lights could be adjusted in real time so as not to stop the traffic when there are no pedestrians wishing to cross. Pedestrian countdown systems encourage pedestrians to clear crossings within the time allocated to them. In short, modern pedestrian and traffic control systems have yet to be fully exploited.

Recent developments in telecommunications have created the prospect of people talking to each other more, of vehicles 'talking' to each other, of vehicles and people communicating with one another, and of vehicles communicating with traffic control systems. This explosion of radio communication raises questions about the availability and rationing of the radio spectrum. On top of congestion on the roads, congestion in the airwaves may well arise (assuming universal network coverage, which at this stage is still not a given).

There are also issues to do with privacy of these systems, and their security against malicious interference. On the other hand, the development of proprietary communications protocols can conflict with open, common standards which are in the public interest.

Finally, electronic route-finding has become something that is taken for granted. This is a technology that is now mature and widely available. The vast majority of urban trips are repeat journeys by people who know their way around, so it is not principally the directions that they are interested in – the thing which is of great value to them is real-time information on unpredictable characteristics of the systems they use: next service arrival times, traffic jams due to incidents, service delays, the availability and location of available parking, and so on. Again, the technologies for delivering this have recently matured and are now readily available at a manageable cost for those who want them, because they piggyback on mobile telephony devices. The coverage and quality of these services will undoubtedly improve as more data is captured and private enterprises develop interesting ways of presenting it. All these new technologies are an enormous convenience, but they do not change the fundamentals.

8 Demographics and industrial structure

Apart from the expected increase in overall numbers, the composition of the population is also likely to change. There will be a higher proportion of older people who are retired or on the point of retiring. At the same time, there will also be proportionately more young adults. Whilst the latter will be 'tech-savvy', the signs are that they may be less well off than their predecessors, and so they might behave differently. This is because of the significant shift in wealth that has occurred away from the young and in favour of the retired, who are no longer the poorest group in society. There has also been a tendency in recent years for income and wealth to become more concentrated on upper-income groups.

However, these changes might be reversed. Overlaying them is the long-term increase in general living standards which, if it continues at its historical rate, will mean that real incomes will double over the next 35 years.

There may be other secular trends of importance, such as the remarkable tendency of young adults to live at the parental home for longer and to delay the age at which they start to have families. These trends might may also stabilise or reverse. Certainly they cannot go on forever. The growth in numbers of young, childless adults might be correlated with a preference for the urban lifestyle. They make more journeys for the purposes of entertainment and leisure, and fewer traditional town-centre shopping trips. So their mobility requirements will differ.

A further material consideration is the extent to which the country's industrial structure continues to develop in business and financial services, or alternatively – as exemplified by the resurgence of the automotive manufacturing industry – reverts towards a stronger manufacturing base. The types of jobs in the new economy do not need to be so place-based, and electronic communications allow the potential of the mobile office to be realised.

9 Design

The new technologies presenting themselves to drivers are precipitating the redesign of vehicles, if for no other reason than to enhance safety in the presence of so much potential distraction. An ageing population also challenges designers to meet their requirements.

Equally, new materials (such as carbon fibre), light emitting diodes (in instrumentation, street lighting, traffic direction and control), new fuels and drive technologies (electricity and hydrogen, and hybrid vehicles) and new regulations (for taxis, for example) all create new opportunities for design.

Changes in the way we share various uses of street space also create significant design problems. The move is now towards 'complete streets' – street design that is not only for the purpose of moving traffic but which recognises all the potential uses of the particular space. Arguably, urban street space always has been shared, but the balance of priorities is changing. Furthermore, having recognised this, some authorities, such as London's government – not least in the Mayor's Roads Task Force – have begun to investigate ways in which more space might be created. For example, where the cost can be justified, putting traffic underground has been considered.

Good design has always been important, and the opportunities to put it to use will continue. We see no reason to think that this will be any different in the future.

10 Freight

As is so often the case, our collection of essays has too little to say about mobility of goods and services. But the urban economy depends upon freight mobility just as much as on personal mobility. And there are strong trends, such as the advent of Internet shopping and delivery by van, towards substitution for personal shopping trips. This is reminiscent of the change in domestic food shopping behaviour occasioned by the advent of the domestic refrigerator.

A useful distinction can be made between retail freight and wholesale. Urban freight will continue to be largely road-based, but offering the possibility of peripheral transhipment and consolidation centres in large cities. However, this will almost certainly require inner-city restrictions on lorry access.

11 Conclusions

Many of the ideas our authors have considered will bring about only evolutionary rather than revolutionary changes in travel behaviour, though some of the technology required to accomplish these incremental shifts might in themselves prove revolutionary.

The possibilities are endless, but even the combined impacts of these changes will be finite. Until we develop something as disruptive – quite literally – as teleportation, we are faced in the foreseeable future with familiar problems: a rapidly rising population, limited road and urban space, a continued desire to get from A to B.

In many ways, the success of initiatives aimed at preserving urban mobility will, certainly in the medium term, be measured not in terms of less congested roads, but by the perception that they are not actually getting busier despite the backdrop of the increased demand for travel driven by population growth.

Technology will be important, but it can create problems as well as solving them. As we have hinted, anything that decreases the time costs associated with travel is likely also to increase, not reduce, demand for movement. Driverless cars might solve safety problems, but they might at the same time add to traffic and hence worsen congestion.

Urban areas are likely to remain a hotbed of competing modes of transportation. Everyone will have their favourite, but it is the mix of modes that make cities work, not the favouring of one to the exclusion of all others.

Much will depend on affordability. What sort of travel can consumers comfortably pay for, and what sort of transport systems can industry and government reasonably supply them with? Overcoming the institutional and funding obstacles to making full use of existing technologies is as much an issue as deciding how to deal with what the future might bring. The past is littered with examples of technologies and products that worked well in principle, but did not stand the harsh test of economic realities.

It is through pricing that government now has the biggest opportunity to influence change. The danger is that policy is muddled and at cross-purposes. Historically we have seen attempts, both by incentivising and by penalising, to influence congestion, air quality, revenue raised, carbon emissions, modal shares and safety. The results have not always been coherent.

We will always face what Donald Rumsfeld called the “unknown unknowns”, but there are plenty of clues and lessons from the past to help us tackle what is to come. And as this volume illustrates, there will be no shortage of clever and imaginative people to help us cope with whatever the future might hold.

2. Coping with the aftermath of peak car in urban areas

– by Christian Wolmar

Transport has two aspects – as the great enabler and as the rampant destroyer. As an enabler, it allows people access to work, leisure and other activities; and modern transport systems do this more efficiently than ever before. There is no doubt that transport improvements have been the catalyst for the rapid economic development experienced since the opening of the railways in 1830, and were the driving force behind capitalism in that period. The relationship between transport investment and economic growth is impossible to unravel, as the two are completely symbiotic.

However, the need to provide for transport facilities has also been a powerful destructive force ever since the world's first railways cut swathes through Victorian cities. Roads, however, because they allow individualised transport in cars – which are far less efficient and far more space extensive than railway carriages – have been far more damaging than the railways. Moreover, they create a whole host of negative externalities, not just by eating up vast swathes of land, but in causing air pollution, noise and even the disruption of communities. This goes for all sizes of road too, right down to even the smallest. The pioneering work in San Francisco carried out in 1969/70 by Donald Appleyard and Mark Lintell (1972) has demonstrated a direct correlation between the amount of traffic on a street and the relationship between people living on it.[1] Put simply, people living on quiet streets were shown to know more of their neighbours, and know them better, than those residing on busy ones.

Such considerations have been ignored for too long, and this has paved the way for a century of car dominance. The future of urban transport must therefore involve a rebalancing of the two aspects of transport – as enabler or destroyer, focusing on the externalities created mostly (but not entirely) by the motor car. These negative impacts have been underestimated for too long, and conventional cost–benefit analyses of road schemes have failed to take into account considerations such as those brought to light by the San Francisco study.

1 The triumph of the car

Ever since the development of major conurbations in the 19th century, a daily war has been fought out on the roads in the urban realm. Originally, in the late 1800s, it pitted horse riders and carriages against cyclists and trams. There was, perhaps, a brief interlude when cars, lorries and motorbuses coexisted relatively well with other users, but soon their speed and power began to

1 In this study, social interaction was defined as "the degree to which residents had friends and acquaintances on the block, and the degree to which the street was a community".

enforce their domination over other road users. It was an unequal battle. Once the red flag legislation was repealed in 1896, there could only be one winner, because of the advantages which the internal-combustion engine had over other methods of traction. As the technology improved and costs were reduced, motor vehicles inevitably gained the upper hand.

The early automobile drivers were not popular in the countryside, as they angered local people by speeding on roads unsuited to fast traffic, causing widespread danger and many casualties. Anti-automobile groups were formed, but the car lobby, backed as it was by the affluent aristocrats who could afford to buy cars, had by the late Edwardian period emerged triumphant, their victory encapsulated simply in a single notion: people and animals had to get out of the way of cars, or be accused of obstructing the highway. This prioritisation, which broadly survives to this day, underpins the urban flow of traffic and has established today's patterns of urban transport.

The march of the car seemed unstoppable. At first, the difficulties that are today so apparent in the urban setting did not come to the fore. Admittedly traffic speeds never seemed to increase (despite the obvious improvement in the type of vehicle being used), but parking was not too difficult given the paucity of vehicles. Meanwhile the carnage on the road was quite extraordinary, reaching a peak of 7,000 a year before the Second World War – but that was perceived as being the price that had to be paid for this improved mobility. One statistic brings exposes the prevailing attitude of the day: 1,536 cyclists were killed on Britain's roads in 1934, which is almost the same number as all road deaths today. While in 1930 it became an offence to drive or be in charge of a vehicle while impaired through drink or drugs, no legal limit was actually set until 1967. Remarkably, wearing a seat belt in the front seats was not made mandatory until 1983, although anchorage points had been a requirement in new cars since the 1960s.

All of this speaks of the prevailing attitude of the time, one which equates the car with freedom, neatly expressed by Nicholas Ridley, one of Mrs Thatcher's transport secretaries who said: "The private motorist… wants the chance to live a life that gives him a new dimension of freedom – freedom to go where he wants, when he wants, and for as long as he wants" (Hansard: House of Commons, 1977). Public transport was of little relevance, and consequently suburban rail networks were shut down after years of underinvestment, while bus networks were cut back. The car would solve every transport problem.

The immediate post-war period marked the total triumph of the motor car, but at the same time exposed the limitations of the ubiquitous use of cars in urban areas. Cars had become cheap enough for the middle classes to purchase, and they were now being used to drive to work. The result was all too predictable, with roads becoming jammed and journey times increased. (And this was not only on weekdays – on a personal note, I remember my parents driving out to their golf club near Egham in Surrey at weekends and being stuck for ages on the Staines Bypass.)

The apogee of this triumphalist phase of the motor car was undoubtedly the publication of the Buchanan Report, *Traffic in Towns* (Buchanan, 1963). The key recommendation of the report was the segregation of motor traffic and pedestrians which, as a result, would have required the construction of a vast network of dual carriageways and feeder roads in every town and city. It was not just the Birminghams and Manchesters of the UK that this would blight , but even modest towns like Newbury, which then had a population of around 30,000.

The Buchanan Report is littered with strange diagrams that overlay massive black and grey lines on mustard-coloured areas of housing – literally a graphic illustration of how town planning and the urban realm was perceived. Newbury – later, in the 1990s, the scene of a major confrontation over its bypass – was to get a full set of 'distributor' roads, aimed at coping with the expected growth in commuting car traffic numbers from 3,000 to 9,000. Buchanan rather ashamedly notes: "We did not construct a peak hour flow diagram for the year 2010 on the basis of the *existing* street system because it was quite obvious that the existing system could not possibly carry the enormously increased loads" (Buchanan, 1963: 62). In other words, much of the centre of Newbury would have to be torn up simply to accommodate the growth in cars. While Buchanan did recognise some of the limitations of the car-based approach, the basic tenet of his report can be summed up in one sentence: "It is necessary to secure comprehensive development or redevelopment of large areas in order to handle motor traffic successfully".

As Buchanan's apologists point out, his report did also contain suggestions for improving other modes, but at its core was the notion that the hearts of towns and cities should be ripped out to make way for the motor car. Buchanan gave intellectual credence to a type of urban and transport planning that was to dominate thinking for the next couple of decades. Urban motorways, built to high standards which required concomitantly greater demolition, were to be constructed in all major towns. The very concept of urban motorways is, incidentally, almost an oxymoron. The very nature of an 'urban' setting is to do with people interacting, but by definition a motorway prohibits any human interaction.

Many towns and cities did indeed succumb to this tempting modernist image. Town centres in places as diverse as Luton, Burnley and Birmingham became little more than thoroughfares for road traffic, with multistorey car parks – if they were lucky – dotted around the edges. Nowhere would have changed more, had these ideas prevailed there, than London. The Capital became the key battleground for the struggle against this concept. Ever since the Second World War, the notion that London would need considerable new capacity to accommodate cars, in the form of a series of ring roads, had become more or less axiomatic among town planners. The only barrier was cost. The British Roads Federation, a pro-roads lobby group, set the agenda and had the ear of ministers.

Although early plans for the ring roads had been set aside, they kept on being resurrected. There was a partial victory for the roads lobby when Park Lane, a short road that runs alongside Hyde Park for less than a mile between Marble Arch and Hyde Park Corner, was turned into a dual carriageway with four lanes in each direction. This incursion into a Royal Park was allowed to go through because Boyd-Carpenter the Transport Minister who was the driving force behind the scheme argued that it was the most important road project of the time: "No single road development scheme could make a greater contribution to the relief of growing traffic congestion" (British Road Federation, 1964). At around this time, too, Britain's first drive-in bank, a branch of Drummonds, opened at nearby Trafalgar Square, demonstrating the thinking that surrounded the future of urban mobility. The notion was that in this era before ATMs, people would drive to Trafalgar Square and cash their cheques without even getting out of their cars – presumably queuing up around the periphery of the square at busy times.

There were to be three motorway ring roads in London, and while the outer one became the M25 and the middle one remained the semi-improved North and South Circular Roads, the crucial inner one was never built – or, rather, only a very small section of it was completed. The idea led to enormous protests under the banner "Homes Before Roads", because the scheme would have entailed the demolition of around 40,000 homes; in the end the policy was scrapped by the Greater London Council soon after Labour gained control in 1973.

Long before the 'Motorway Box' (as the proposed inner ring road became known) was scrapped, things had been changing. In 1960, traffic wardens first appeared. They did not suffer from the opprobrium with which they are treated today. Indeed, they were welcomed as necessary for bringing order to the chaotic state of parking, and were immortalised in the Beatles song 'Lovely Rita'. Clearways, the precursor to today's red routes, were introduced in the 1960s to smooth traffic flow. The first bus lanes were introduced in London and Reading (originally as a temporary measure to replace a trolley bus) in 1968, and controlled parking zones soon followed. In 1973, Carnaby Street, the famous fashion street so beloved of the youth of the day, was pedestrianised, resulting in a 30% increase in footfall; and the process to pedestrianise Leicester Square was begun – though it took a couple of decades for it to be completed.

While a few urban roads were still being built or widened, by and large the process had ground to a halt by the early 1990s. Indeed, in some places a reversal had begun, with the streets being reclaimed. In Bristol, the architectural and spatial integrity of the 18th-century Queen Square had been ruined by the construction in 1936 of a dual carriageway cutting it in half. By 1990, 20,000 vehicles were driving through the square daily and it appeared to be such an integral part of the city's road network that nothing could be done to restore the area to its former status of one of Bristol's green lungs. However, in 1993 the dual carriageway was closed, and by the end of the decade, just in time for its 300th anniversary, the lawns and paths had been restored. In the centre, below the statue of King William, there is an inscription commemorating "the return of this historic space to the citizens of Bristol".

An even more radical change was brought about in Birmingham. In the 1960s, a series of inner ring roads and roundabouts were built in Birmingham to serve the shopping centre known as the Bull Ring. They represented a kind of triumphal celebration of the city's role at the centre of the country's car industry, but proved unpopular with pedestrians, who were forced into a series of subways as they had to be entirely separated off from the fast-running traffic above. By the 1980s changes to the design were being mooted, and in subsequent years several sections of the ring road were removed to create a more pedestrian-friendly town centre.

2 Today

We cannot begin to understand the future of urban mobility without a thorough understanding of this history. It is important to an analysis of the future, not least because many developing countries are to this day in the throes of the kind of battles which still cannot be laid to rest here in the Western world, while there they rage in their starkest form.

Moreover, the process of change is evolutionary rather than revolutionary. This means that even though many people recognise that it was right to scrap London's ring roads and rescue Bristol's Queen Square from its 1930s desecration, there are still others who believe that the future of urban mobility in towns should continue to be centred around motor traffic. While its worship is no longer so unconstrained, the car is still viewed as a solution with scant regard paid to its downsides. One only has to view any car advertisement and see how it portrays the fantasy world of the motorist unencumbered by any other vehicles to realise that this ethos still lives on.

There have been some attempts to address the issue of liveability in urban areas. The 'home zones' which found favour briefly during the Blair government were a concept imported from the Netherlands that involved redesigning streets in such a way that it was possible for children to play in them safely and for people to cycle along them without fear. While some 60 home zones were introduced, they tended to be highly engineered and expensive, and were not universally well received. Overall, however, they were deemed a success; but rather than working to develop and improve the concept, central government quietly abandoned the programme, though some developers and local authorities remain interested in introducing them.

The dystopian vision of Buchanan and his ilk has been discredited, but it has not entirely gone away. The car is still seen as the solution to urban mobility by many local authorities and politicians. Andrew Adonis, the former Labour transport secretary, for example, would like to see a series of river crossings built over – or under – the Thames east of Tower Bridge (Adonis, 2014), and Transport for London (TfL) is pursuing the idea. Plans for a tunnel at Silvertown were sent out for consultation in October 2014, and plans for crossings at Gallions Reach and Belvedere are also being pursued. Initial public soundings are in favour, but that support may wilt away when people realise that the likely scenario is that all the new crossings, as well as some existing ones such as the Blackwall Tunnel, would be tolled.

Boris Johnson has also mooted the idea of a series of tunnels being constructed at vast expense. He has suggested that this could be funded by selling the road space that would be freed up as a result of reducing car numbers on the surface. However, this appears unfeasible, since many of the roads would have to remain in place as access for housing or shops, even if they could be made narrower. Moreover, access to the tunnels would require a series of slip roads, which would result in extensive demolition; the overall impact would merely be to increase the number of cars.

Even those who accept that there must be a central role for public transport in the future of urban mobility, and who put forward ideas for solutions that require taking what they would argue is a balanced position, are in reality suggesting that there should be more of everything: public transport, road space, railways capacity, and so on.

This ‘let’s do everything’ approach is probably best encapsulated in the report published in the summer of 2014, *The London Infrastructure Plan 2050: A consultation* (Greater London Authority, 2014), which was little more than a list of major projects ranging from links to the Thames Estuary airport (which was subsequently ruled out by the Airports Commission) and a new orbital railway around London, to the series of road tunnels favoured by Johnson to take traffic off the surface level, and the numerous river crossings. It is in the style of ‘predict and provide’ – or, even worse, it is in the nature of a child’s birthday wish list which does not take into account constraints in the budget or other resources. In this gluttonous approach, there are no hard choices, or even real decisions, to be made – except where to get the money and how to appease those directly affected by the construction.

It is a methodology that is neither realistic, nor desirable. While there may be some private money available to make up for the reductions in urban transport budgets, it is very unlikely that ‘megaschemes’ such as a series of underground tunnels in a major city would, today, be fundable without a major change in policy.

There is, of course, one possible source of such riches, and that is road pricing. This is almost universally seen as desirable by transport planners and experts, but equally almost as universally rejected by politicians, who are by and large more concerned with their re-election than with long-term issues such as climate change and obesity. Even if the political obstacles could be overcome, the most comprehensive road charging scheme would probably not pay for the kinds of megaschemes envisaged in the GLA consultation. Nor would public–private partnerships, since they have somewhat gone out of fashion in the transport realm following the debacle of the London Underground scheme. The key question is whether such major schemes are desirable or necessary, and this is addressed below. However, the issue of technology needs to be addressed first.

3 Technology

The notion that change will be evolutionary rather than revolutionary is even true of the coming of the ‘driverless car’, despite the radical nature of the new technology currently being developed. There is much excitement among some commentators about the notion that the drivers will soon become redundant and will be able to sit and read the *Financial Times* while being driven to work by their automatic vehicles. We are a very *very* long way off from this. Even though a handful of Google cars are rapidly ratcheting up miles in California, there are a whole host of problems to overcome, decisions to be taken, technologies to be developed and investments to be made – quite possibly by public bodies – before this becomes feasible. Moreover, there will be a long period of transition during which driverless cars will need to interact with traditional vehicles.

The driverless car will not suddenly change the way we live. Besides, if it is to be a positive force, key regulatory decisions will have to be made. There are also some fundamental ethical questions to be answered: who, for example, would be responsible if two driverless cars did somehow collide, and their occupants were injured or killed?

While computer-driven cars, to give them a more accurate name, would reduce accidents and be safer – they would not jump lights or attempt to squeeze past cyclists – there are numerous possible downsides. They might well encourage a flight away from public transport, further escalating congestion. If a car had the facility to drive itself home or to a parking space, that would undoubtedly increase the number of vehicles on the road. Therefore to see driverless cars as a panacea for, or a solution to, the problems facing urban mobility in the future is naïve in the extreme. It is unclear what problem driverless cars would solve. They would not reduce congestion, and may in fact increase it. They would not reduce energy use. The assumption that they would be communal in the manner of car clubs, and that therefore people would not need to own their own cars, is tenuous. The idea that we will soon all be hopping in a pod to get to work and then send it packing to find its own parking space, or to be used by another passenger, is not realistic, feasible or desirable.

While, as an aside, car clubs do have a role to play in reducing the number of parked cars on urban streets. they do not address the fundamental aspect of the negative externalities generated by motor vehicles in the urban setting. As Taras Grescoe wrote so accurately in his book *Straphanger: Saving our cities and ourselves from the automobile* (Grescoe, 2012: 12):

> “Even if a zero-emission miracle sedan, running on tap water and yielding only lavender-scented exhaust, appeared in dealerships tomorrow, it would not solve the fundamental problem with cars. The automobile was never an appropriate technology for the cities of America. As a form of mass transportation for the world, it is a disaster.”

The establishment of electric cars will be an equally slow and convoluted process, and their advantages in environmental terms will only be realised if electricity is produced more sustainably, which belies current trends. It is by no means certain that even within the timeframe of the next 35 years, i.e. to 2050, that electric cars will be the norm. It is salutary to note that the first electric cars appeared in the late 19th century, simultaneously with those powered by internal-combustion engines, and there have been numerous failed attempts in the past to turn them into a viable alternative to conventional vehicles.

In terms of my own personal experience, I remember the Harrods deliveries in my youth in Kensington arriving in electric vans, and some 30 years later, in the mid-1990s, driving a conventional-looking Ford Fiesta with an electric engine in a pilot scheme in La Rochelle in western France. Despite the introduction of some charging points and the advances in vehicle design, sales have been poor – not least because there is still a price differential, even when the £5,000 government grant available is taken into account. Moreover, there are practical problems still to be overcome, such as restrictions on cables running from houses outside onto conventional streets, to recharge parked cars. In 2013, only around 2,500 pure electric cars were sold in the UK, although this number increased considerably in the first nine months of 2014 to 4,500, with around the same number of plug-in hybrids sold.

The electric car currently and for the foreseeable future only fulfils a niche market role. It is seen by manufacturers such as Renault as suitable for people getting a second car, or for one that they don't intend to use a great deal. Their potential to become a mass-market alternative to the existing fleet appears limited by both technology and consumer choice, despite regulatory efforts to encourage their use.

Although for different reasons, the same goes for cars powered by hydrogen fuel cells. Despite the commitment of Toyota to focus on hydrogen fuel cell cars rather than battery electric vehicles, their price remains prohibitive, and the issue of the safety of both the cars themselves and the filling stations remains a major consideration.

The key changes in technology are more likely to be those related to information and data provided to car users, such as the apps for bus passengers and navigation aids for cars drivers that are fast becoming universal. The information available to make the right journey choices and to enable people avoid disruption is becoming ever-more sophisticated and widely used. Further developments are inevitable, and will arrive much sooner than those pertaining to the nature of the vehicles actually being driven in towns and cities.

4 Demand

The important point to recognise is that the century-long rise of the car has not only been halted, but has now given way to the beginnings of a move in the other direction. In London for example, the modal share of the car has fallen from 50% in 1990 to 38%. Manchester and Birmingham are beginning to experience the same trend. According to David Metz, we have reached the end of the third era of travel. The first was when we were hunter–gatherers, limited by our need for food; the second began when we developed agriculture and settled into communities that were reached only by walking or on horseback; and the third began in the 19th century, when we started burning fossil fuel to provide power for, first, railways then motor vehicles. This has now reached its limit and growth has begun to tail off for a variety of reasons, but essentially because traditional demand factors are no longer operating: young people, in particular, are learning to drive later, and prefer public transport so they can use their mobile devices; meanwhile there is a trend towards agglomeration of businesses of similar kinds, particularly IT firms, which makes travel unnecessary. Developments have concentrated on brownfield sites, where non-motorised journeys are easier. Consequently the number of miles travelled per person has stopped rising.

Metz (2014) argues that successful world cities are those with “a growing population… and a declining share of journeys made by car”. Metz summarises past transport policies harshly (Metz, 2014):

> “Many transport professionals are trapped in outdated modes of thought and are overlooking new trends in travel behaviour. Some past transport investment has been damaging, while beneficial investment opportunities have been neglected… huge expenditures on transport infrastructure are planned in Britain based on obsolete analysis of the supposed benefits and over stated forecasts of the demand for travel.”

Transport policy has been characterised by the ‘let’s do everything’ approach encapsulated in TfL’s 2050 report. We want better roads, more buses and faster trains, all improved by new sophisticated information technology. It is time not only to shift away from the emphasis on cars, but also to make hard choices. There is neither the money nor the resources to demand the range of transport infrastructure which the ‘predict and provide’ model suggests is needed. There is, incidentally, an asymmetry here. The policy towards roads has tried to address peak transport demand, adding capacity that may be used for only an hour or two in 24. Yet, on the railways, no parallel attempt has been made. It is merely accepted that rail commuters will have to stand, at times for the duration of long journeys, or simply wait for the next train. Ultimately, in terms of resources, this may be the most sensible policy, but it has certainly disadvantaged rail in relation to road.

Lynn Sloman argues that research shows it is possible to dampen down car use demand through a series of ‘soft’ measures, ranging from better marketing of bus transport, and school and workplace travel plans, through to encouraging car clubs and car sharing. This is much more fiddly and less exciting for politicians than grand projects for new highways and bridges, but it has proved to be effective. She reports (Sloman, 2006: 176): “We concluded that the soft actions we had looked at could indeed potentially cut traffic by a quarter (26%) in the busiest places at the busiest times.”

5 Who moves and why?

It is easy to forget what the transport business is all about. It is not about travelling but about getting there. Yet, the basic goal of transport planning in the past has been to increase mobility – to make it easier to get around. However, that is the wrong metric. Mobility is not an end in itself, nor are the so-called 'time savings' which are seen as the principal output of infrastructure schemes when cost–benefit techniques are applied. The real measure should be accessibility – but that is much harder to quantify.

It is ease of access that is the key quality in a city rather than mobility. Cities create easy access by bringing together, within a short distance, many facilities – and also by providing good transport between them. The goal of transport there is to facilitate improved access, and not, as is wrongly stressed, simply to speed up journeys. That is why urban planning and transport are inextricably linked. Planning decisions determine transport outcomes, yet they are often made in a vacuum.

The difficulty is in finding ways to measure accessibility. This can be done on a micro level, by assessing how far every inhabitant in a city is from relevant facilities, such as schools, hospitals, major employment centres, shopping districts and so on. However, this is obviously painstaking and very expensive, and therefore unrealistic. Nevertheless, in putting forward major transport schemes, such considerations should be taken into account.

There is, too, another metric that is frequently ignored when transport schemes are put forward, and that is the income class of those affected. It is axiomatic that road schemes are likely to favour the better-off, as they are more likely to have access to cars (there is a bit of an exception to this in central London, where lots of very well-off people do not own cars). Moreover, schemes to improve railways, which tend to be used by more affluent groups, are therefore less helpful to the urban poor than those which boost bus services.

6 Conclusions

The commitment by John Prescott, who headed the large merged Department for Environment, Transport and the Regions in the early Blair years, to "get people out of their cars" failed because the political will was not there. As he said at the time, his efforts were stymied by 'teenyboppers' in Number Ten terrified of the impact that any policies which might be perceived as 'anti-car' would have on the electorate. That remains the case today. The fact that the immediate and medium-term future will look very much like the present is a result of the failure to take on board the imperatives of climate change, the obesity crisis and the damaging effect of reliance on the car. For every policy advocating more cycling or a reduction in car use, there are others which militate against such progress. Planning policies in urban areas have veered wildly over time and between authorities. Sometimes authorities simply bow to the notion that car use is inevitable and therefore developers are encouraged to accommodate them, even though it is obvious that this in the face of policies aimed at reducing greenhouse gases. At other times, attempts have been made to restrict their use through not providing space for them.There is no cross party consensus – or indeed a coherent view within any of the major parties.

Lynn Sloman in her book *Car Sick: Solutions for our car-addicted culture* concludes that “It is possible to cease to be so dependent upon cars, and if we did this, the places where we live would be cleaner, safer, more peaceful and healthier” (Sloman, 2006: 177). Prescott understood that, and transport planners and urban designers know it, but the fact that so far climate change has had little impact (apart from the odd megastorm), that obesity is a problem that grows incrementally and not as a sudden explosion (though it is certainly a phenomenon observable by anyone who frequents shopping centres regularly) and that the pollution in the air is now largely colourless (unlike the smogs of the 1950s) are clear indications that policy changes have been sloth-like.

This is not about London, a city which is in many respects a special case. Every town and city should have a transport plan. Such plans should take into account all modes, and ought to be based on the notion that car use should be reduced. While the deregulation of bus services, and the lack of regional authorities that cover whole conurbations rather than merely parts of them, make such planning difficult, it is still not an impossible task. Whereas in large towns there should be an emphasis on public transport, smaller places could do much to bring about a rapid shift to cycling, given that travel distances within them tend to be short.

The future, in terms of the two or three decades, is therefore not about developments in technology, such as driverless cars and so-called ‘smart cities’, but is for the most part about the same old machines – cars, trains, trams, buses and so on – and how to accommodate them and use them more efficiently. As I write, the *Evening Standard* reports (Beard, 2014) that ‘driverless’ trains – the sloppy journalistic term for unstaffed trains – will not be introduced on the London Underground until at least 2025, and probably not before 2030. And it is a darn sight easier running ‘driverless’ devices on tracks controlled by signals than it is on the higgledy-piggledy network of roads in our towns and cities.

The future, just like the past, will be more about politics than technology – about sorting out conflicts between the modes, and adapting policies to address major issues such as climate change, increasing fuel prices and population growth, rather than waiting for technology to provide ultimate solutions. The future will look more like the past than many people expect. Consequently, the issues that need to be addressed, and the decisions that need to be made, will remain largely the same. We should not dodge them while waiting for the nirvana of new technology, whether it be electric cars, driverless vehicles or teleportation.

A coherent policy on the future of urban mobility must rebalance the advantage that has been given to the car over the past hundred years. For reasons of environment, economics, commerce and liveability, the emphasis has to be on modes other than single-occupancy car use. A new policy must, too, have at its heart the notion that it is accessibility, and not mobility, that should be the prime ambition for our towns and cities. And this policy must also concern the urban realm in general, and not limit its focus to transport and its consequences.

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3. Trends in urban travel behaviour

– by Scott Le Vine & John Polak, Imperial College London

1 Introduction

Few informed observers would dispute the notion that the early 21st century has been a period of flux for the transport sector. This volume is by its nature forward-looking – the future of urban travel – but it is necessary to set out on this journey by first establishing the current landscape and how it has come to be.

The 2000s began inauspiciously from a transport perspective – with public disorder motivated by the Fuel Price Escalator. Much of the discussion that follows throughout this volume is technical in nature, but this serves as a stark reminder that policy choices that will guide future urban mobility in Britain will be contingent on the public's will.

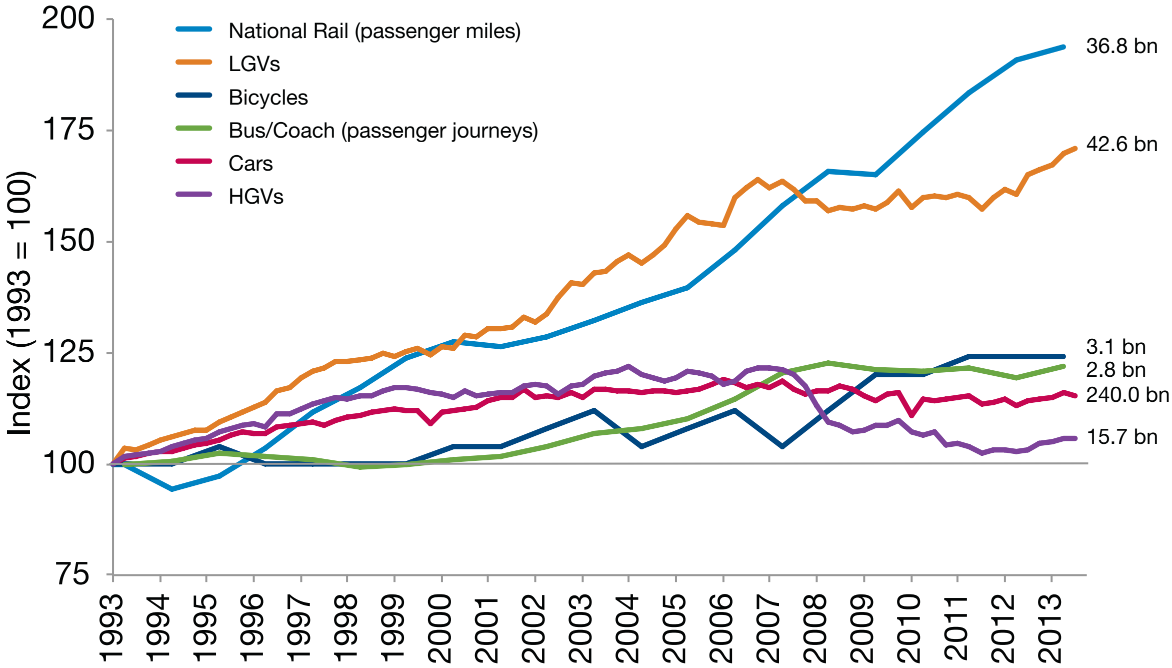
The Fuel Price Escalator is a classic example of targeted, conscious policy stimulus, but in hindsight it is also clear that a number of decentralised social, economic and technological shifts were also underway as the 21st century commenced. Perhaps a few select professionals grasped the far-reaching consequences for mobility in British cities; however, it is no exaggeration to state that the industry was taken by surprise in a number of ways. Indeed, at the time of writing there remains vigorous scholarly and professional debate regarding why urban mobility in the 2000s has been distinctive, and the implications for the practice of transport planning. A tangible manifestation is that the Department for Transport (DfT) is now engaged in a major initiative to extend its capabilities to represent uncertainty in road traffic forecasts (which currently extend to the year 2040).

Figure 3.1 shows trends in usage of selected forms of transport across Great Britain. In the two decades since the early 1990s, passenger rail and light goods vehicles (LGV) (van) traffic have grown most sharply, with the expansion in national rail traffic remaining robust after the 2008 recession. Though there is little hard evidence, it has been suggested that information and communications technology (ICT) may have played a role in both of these trends – through heightened demand for delivering (primarily via LGVs) shopping purchased online. Both LGV and heavy goods vehicle (HGV) traffic were affected by the recession, with each of the two showing upward trends since 2011. Car traffic has remained essentially flat in the aggregate, and despite the growth in LGV use cars account for the large majority of all road traffic. In 2013, about 6 times as many miles were driven in cars than LGVs, and there were 15 times as many car miles driven than HGV miles.

Though road traffic remains around 2% below the level just prior to the recession, the latest data shows quarter-on-quarter increases in road traffic for four of the five most recent quarters (between Q1 of calendar-year 2013 and Q2 of 2014, with the latter level around 2% higher than the former). As will be seen shortly, however, a broadly stable level of overall road traffic during a period of steadily increasing population (the UK's population increased by 5% between 2007 and 2013) means that there has been a sustained decrease in road traffic per capita.

Trends in bicycle and bus travel are also shown in Figure 3.1. Both trended higher in the 2000s – earlier for bus travel than cycling. The overall upward trend for both of these two forms of transport (bus and cycling) is the result of quite divergent trends occurring in different types of places. As will be seen, this reflects not simply urban versus rural divergence, but also disparate trends occurring in cities of different sizes.

Figure 3.1: Traffic in Great Britain by selected forms of transport



Note: Indices of vehicle miles except as otherwise noted
Source: ORR (2014); DfT (2014a; 2014b; 2014c; 2014d)

In due course, trends affecting urban mobility will be discussed, but first the term 'urban' – used rather imprecisely by professionals and lay persons alike – requires exposition. The headline findings of the United Nation's (UN) seminal world-population studies are widely quoted: whereas 30% of the world's people lived in urban areas in 1950, the 50% threshold was passed in 2007 and the trajectory is upwards for the foreseeable future, to reach 66% in 2050 (UN, 2014). Careful readers, however, will note that the authors make no attempt to reach a common global definition of ‘urban’ – the sharply divergent definitions employed by each country’s government are employed unquestioningly.

As in the world at large, so goes Britain: Scott et al. (2007) report the use of no fewer than 30 definitions of urban/rural used by government departments in the UK.

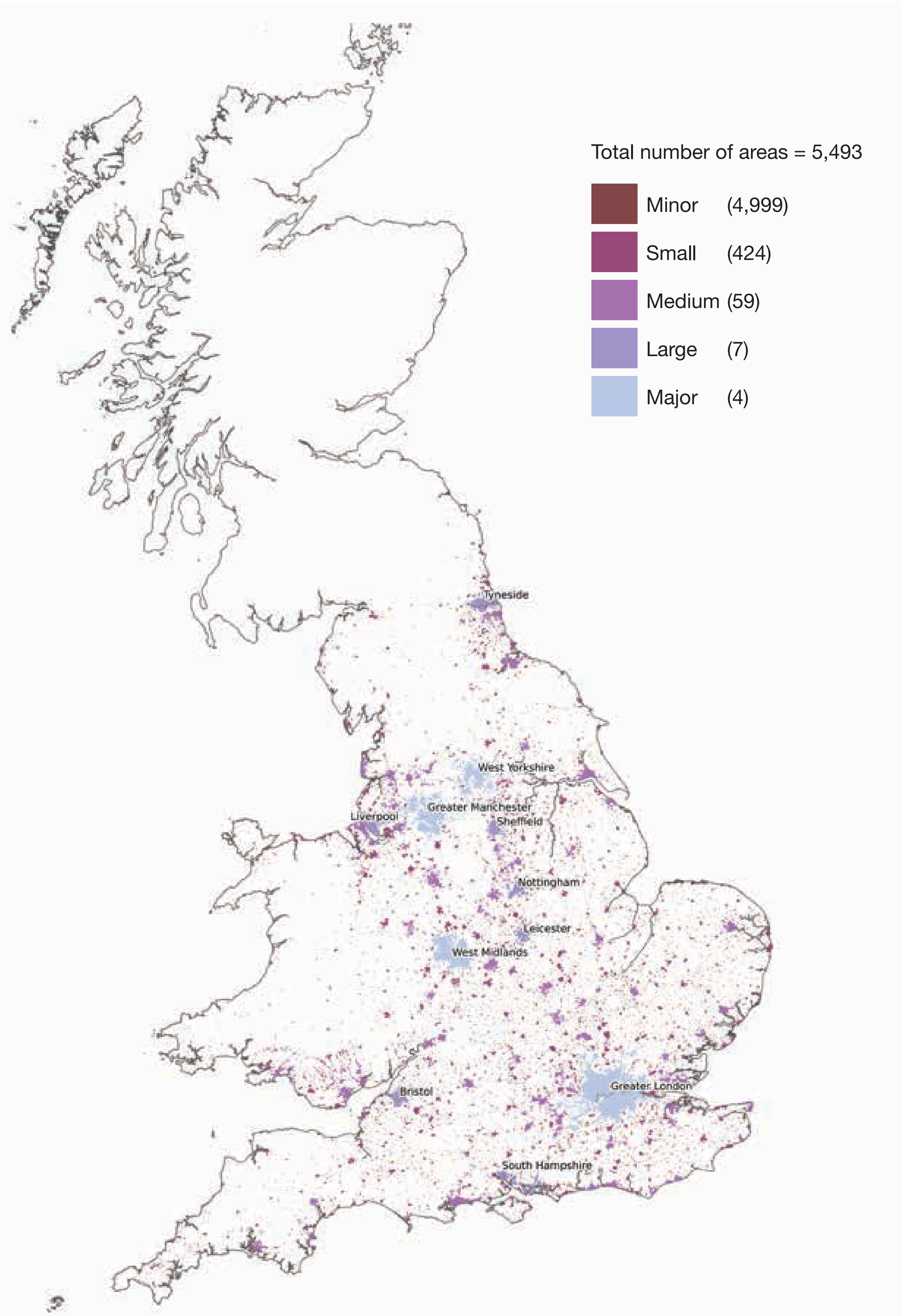
Despite only 9% of land in England being developed, Table 3.1 shows that 95% of England and Wales residents live in the Office for National Statistics’ (ONS) definition of ‘built-up areas‘ (settlements of at least 20 hectares, approximately 50 acres, in size, see Figure 3.2), with four fifths (82%) in settlements of greater than 10,000 population. Many lay persons would not consider the lower end of this spectrum to be genuinely ‘urban’ in the popularly understood sense, and using an alternative (equally as arbitrary) lower limit of 250,000 population the ‘urban’ share of the England and Wales population by this definition is around one half (49%). In addition to the set of thorny in-principle questions of how to define ‘urban’, further imprecision arises from the frequent colloquial use of the term ‘city’ to describe issues that affect the local authority level of government, whether in an urban or rural context.

Table 3.1: Proportion of the England and Wales [combined] population living in built-up areas of various sizes, as recorded in the 2011 Census

	Number	Percentage of England and Wales population
London (9.8 million population)	1	17%
All BUAs* over 1 million population	4 (London: 9.8 million, Manchester: 2.6 million, Birmingham: 2.4 million, Leeds: 1.8 million)	30%
All BUAs over 500,000 population	11	39%
All BUAs over 250,000 population	29	49%
All BUAs over 100,000 population	70	60%
All BUAs over 50,000 population	127	63%
All BUAs over 25,000 population	227	74%
All BUAs over 10,000 population	494	82%
All BUAs	5,493	95%

* BUA: Built-Up-Areas
Source: ONS (2014b)

Figure 3.2: Built-up areas, 2011 Census, England and Wales



Source: Based on ONS (2013: Map No. 1)

When measured against Britain's other urban areas, London is indisputably in a league of its own – it is a first-tier node of the global economy, a peer in many respects to only New York and Tokyo. It is arguably Europe's only megacity (with Istanbul, Moscow and Paris also staking claims). And because of London's position near the top of elite cities globally (behind only New York, by the Economist Intelligence Unit's (EIU) reckoning), it thoroughly dominates the rest of Britain's urban system. Birmingham, assessed by the EIU to be the next-most-globally-competitive British city, does not crack the top 50 worldwide (and is No. 16 in Western Europe) (EIU, 2012). London's economy is estimated to be more than five times as large as Leeds' and Manchester's economies combined (Centre for Cities, 2014).

Despite its position at or near the top of indices of global influence, in recent decades London has drifted down the international league table in terms of population size, from No. 18 in 1990 to No. 27 in 2014. This trend is projected by the UN to continue (to No. 36 in 2030) despite sustained growth forecast in London; this is caused by faster urban growth in other parts of the world (particularly in Asia and Africa). London's dominant position must also be kept in perspective in the British context. Just a sixth (17%) of the England and Wales population live in the Greater London built-up area, and even among people living in urban areas of over 250,000 population only a third (35%) live in London. What is more, the majority of Londoners live in Outer London (which is a much less distinctive urban environment than Inner London is).

The Sceptred Isle is expected to become increasingly 'urban', regardless of how one defines the term. Central government does not prepare population projections separately for rural versus urban areas; however, the ONS's current ('2012-based') local-authority-level projections for England imply continued urbanisation. There is strong and positive statistical correlation (+0.34) between year 2012 population density (in persons per hectare) and the rate (in percentage terms) of projected population growth up to 2037 (the most distant year studied). In part, this reflects a projection of much more robust population growth in London than elsewhere in England (28% versus 14%), but even leaving Greater London aside there remains a positive statistical relationship (+0.08). These future projections do not represent a foregone conclusion, however; they are constrained neither by the presence (or scarcity) of developable land nor by planning restrictions. In reality, the nature of new building has in the recent past proven to be quite variable: the average density of new residential building in England was stable throughout the 1990s, then increased year-on-year from 25 units per hectare in 2001/2 to 43 in 2007/8, and has since plateaued at this higher level. Where the expected future growth in Britain's population will go (and how it will be housed) will play a structural role in shaping future urban mobility patterns.

Whereas the preceding discussion suggests increasing polarisation in the population distribution, an analogous process of economic differentiation has also taken place across Britain's urban areas. When Gross Value Added (GVA;

a measure of a region's economic activity) in 1997 is compared with the rate of GVA growth over the subsequent fifteen years (to 2012) at the NUTS2[1] level of geography, one finds a quite strong statistical correlation (+0.57). In other words, the largest urban economies grew more quickly than smaller ones.

This is partly due to the increasing economic power of London, particularly Inner London. Inner London's share of the UK's GVA increased from 12% in 1997 to 16% in 2012, while Outer London's was stagnant at 7% (Outer London in fact grew somewhat more weakly than the UK as a whole). Table 3.2 compares the economic structure of selected areas (NUTS2 geography); Inner London is also the only region shown in Table 3.2 where the employment rate increased in the fifteen years to 2012. An autumn 2014 report by Transport for London (TfL) highlighted the divergence in economic performance in Inner versus Outer London as a contributor to traffic patterns in the 2000s (TfL, 2014). However, even if all of London is removed from this analysis, there was – similar to when population growth is investigated – still a tendency (a correlation of +0.08) for economic growth between 1997 and 2012 to concentrate in places (at a NUTS2 level of geography) that already had relatively well-developed economic bases in 1997 (as measured by GVA).

Table 3.2 shows further evidence of spatial sorting when economic activity is investigated for selected urban areas and economic sectors. It can be seen, for example, that the finance/insurance/real estate (FIRE) sector increased as a share of the economy across the UK, but by seven percentage points in Inner London (where it was already highly concentrated) versus four percentage points nationally. Likewise, the Public Administration/Education/Health sector combined to account for just 12% of Inner London's economy in 1997 (versus 17% nationally), and by 2012 this sector had increased its share nationally but not in Inner London. The manufacturing sector also shows evidence of heightened spatial differentiation, with Inner London's already small share (4% in 1997, versus 19% nationally) decreasing towards zero.

1 NUTS (Nomenclature of Units for Territorial Statistics) is a hierarchical classification of administrative boundaries used by Eurostat. In the UK, NUTS1 is the English regions, Northern Ireland, Scotland and Wales. NUTS2 is a set of 37 counties and groups of local authorities.

Table 3.2: Trends (1997–2012) in Gross Value Added for selected British regions (NUTS2 geography)

	Inner London	Outer London	Greater Manchester	West Yorkshire[a]	Merseyside	Gloucestershire, Wiltshire and Bristol/ Bath area	UK
FIRE[b] sector as % of GVA[c] (1997→2012)	30% ↗ 37%	11% ↗ 12%	13% ↗ 20%	16% ↗ 20%	15% → 15%	16% ↗ 20%	15% ↗ 19%
Public administration/ Education/Health sectors as % of GVA (1997→2012)	12% → 12%	15% ↗ 19%	18% ↗ 21%	18% ↗ 21%	23% ↗ 25%	18% ↗ 20%	17% ↗ 19%
Manufacturing sector as % of GVA (1997→2012)	4% ↘ 1%	13% ↘ 6%	20% ↘ 10%	23% ↘ 12%	23% ↘ 16%	20% ↘ 13%	19% ↘ 11%
Growth in GVA in nominal terms (1997→2012)	+130%	+68%	+76%	+76%	+81%	+79%	+80%
GVA, billions (2012)	£216.1	£93.3	£51.0	£42.9	£25.3	£53.7	£1,356.6
Employment rate, ages 15–64 (2002→2012)	68% ↗ 71%	76% ↘ 74%	73% ↘ 71%	73% ↘ 72%	70% (2012; 2002 not available)	80% ↘ 78%	75% ↘ 74%

a 'West Yorkshire' as defined here comprises: Bradford, Calderdale and Kirklees, Leeds and Wakefield
b FIRE: Finance/Insurance/Real Estate
c GVA: Gross Value Added
Source: ONS, 2014b

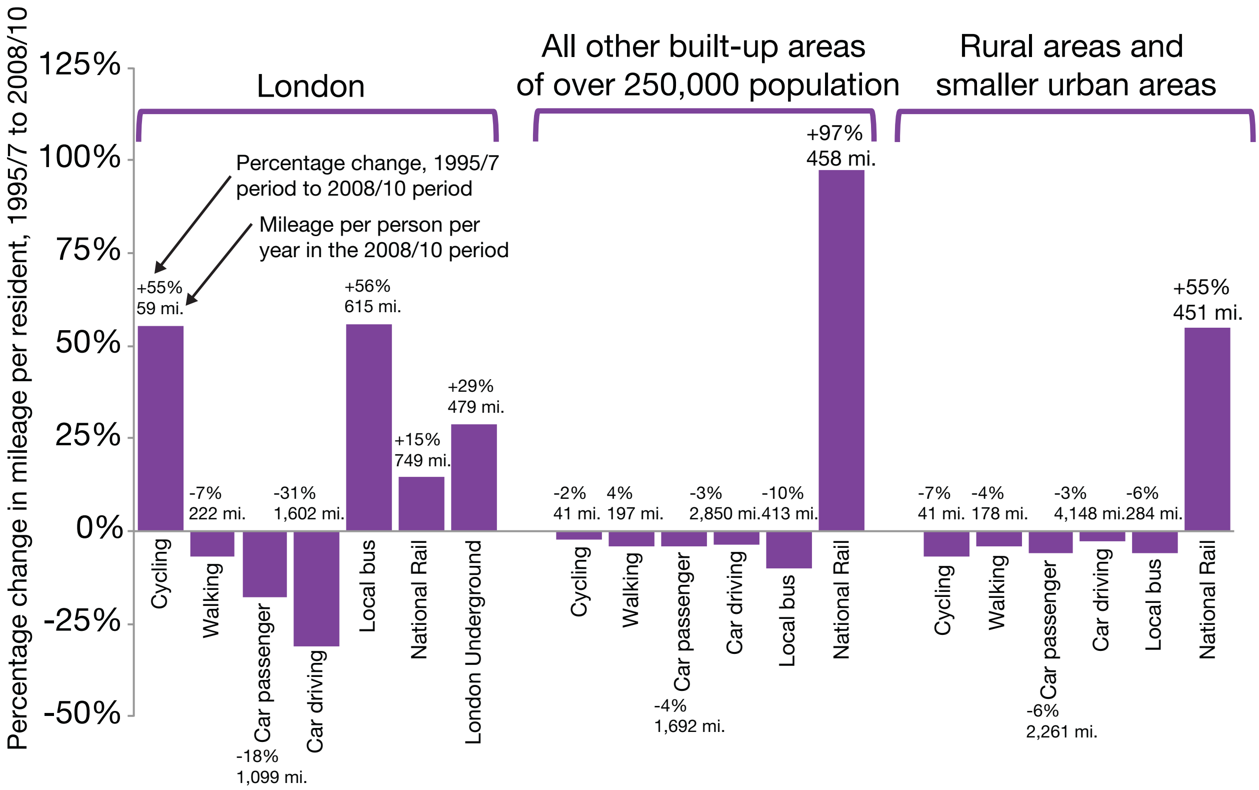
2 Spatial and socioeconomic trends

It is generally accepted that the demand for transport is derived, that is it is dependent in large measure on wider demographic, economic and spatial trends. It is here that developments have caught transport researchers flat-footed.

Whereas Figure 3.1 shows national transport trends since the mid-1990s, Figure 3.3 provides per-capita patterns in London separately from other urban areas (of over 250,000 population) and also from the rest of Britain.

National Rail increased in all three of these types of places, and both walking and car travel decreased – but the similarities end there. Car driving decreased in London throughout this time period, whereas in both other areas car driving mileage per capita increased up to the 2008 recession (+7% in places of 250,000+ population; +3% in smaller built-up areas and rural areas) and only then decreased. Both cycling and bus mileage per capita increased by greater than 50% in London, but decreased outright elsewhere. In 2008/10, car driving mileage per capita was 44% lower in London than in other areas of 250,000+ population, and 61% lower than in the under-250,000 settlement-size class. Even in London, however, mileage per capita in cars (driving plus passenger) was nearly 50% greater (47%) than on public transport (bus, underground and national rail combined).

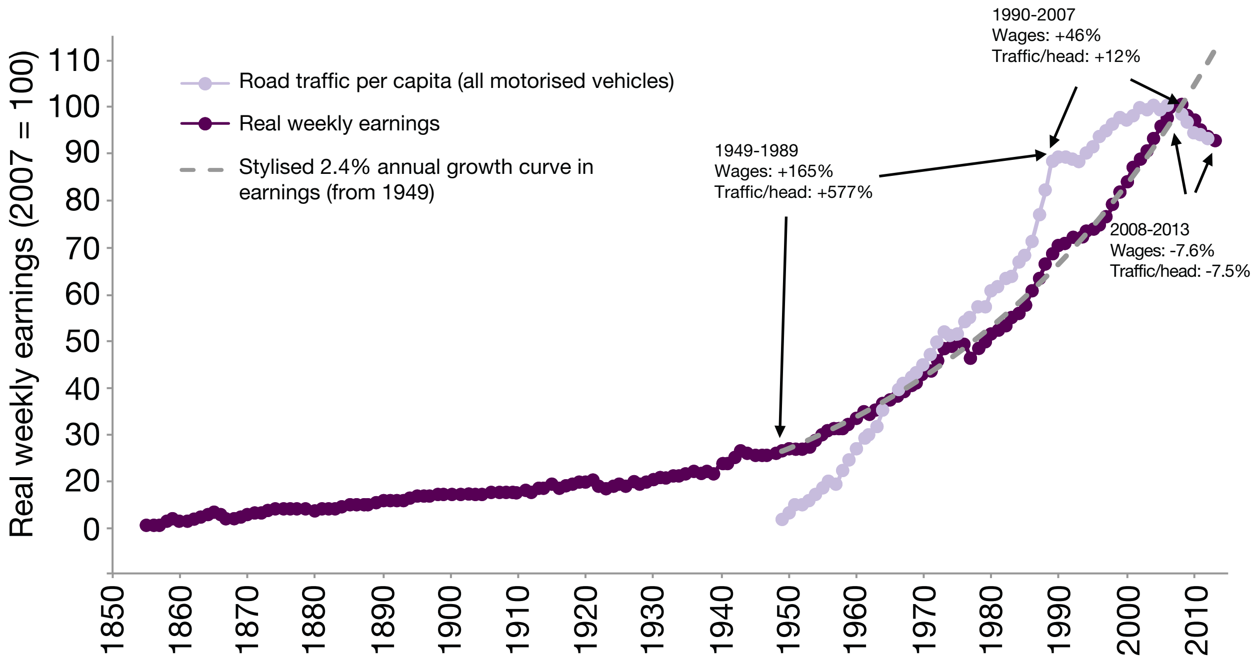
Figure 3.3: Trends in urban mobility by selected modes of transport, 1995/7 to 2008/10



Source: Authors' analysis of GB National Travel Survey microdata (Morris et al., 2014)

One of the traditionally strongest statistical relationships in transport has been between economic activity and road traffic. On closer inspection (see Figure 3.4), three distinct periods of this relationship can be identified. First, between the 1950s and 1980s road traffic per capita tended to increase much faster than earnings, while from 1990 to 2007 (the second regime) the opposite was true. This was clearest in the latter part of this period, as traffic levels per capita were essentially unchanged from 2002 to 2007 despite a 13% increase in real wages. The third of these regimes encompasses the period since the onset of the 2008 recession, and it is worth noting here that the recovery from this recession has so far been markedly weaker than the historic experience. Wages have fallen by an unprecedented 8% since 2008 with no indication (as of 2013, the latest data available at the time of writing) that a trough has yet been reached, and this is nearly perfectly mirrored by the trend in road traffic per Briton during this time period (also -8%).

Figure 3.4: Real weekly earnings per worker (1855–2013) and motorised road traffic per capita (1949–2013), indexed 2007=100



Sources: Wages: Bank of England (in OBR, 2014); Road traffic: DfT (2014d: Table TRA0101)

From these observations, two forward-looking questions are of structural importance for future traffic levels:

- **First:** Will the British economy return to the historic pattern of annual growth in excess of 2% in both labour productivity and earnings? In its long-term economic forecasting, central government (through the Office of Budget Responsibility (OBR)) is currently projecting a return to 2.4% trend growth to occur in the mid- to late 2010s, but whether this will actually take place cannot be known in advance with certainty (OBR, 2014). OBR currently forecasts a UK population of 76 million in fifty years' time (+19% over the 2014 population), with a UK economy that is more than three times as large (in terms of inflation-adjusted GDP) as in 2014. The implication is that the average Briton will be 2.5 times as well off materially in 2064 as in 2014; the extent to which this projected economic growth occurs – and how it is distributed among Britain's cities – will of course have very large consequences for the nature and magnitude of urban mobility.

- **Second:** Which of the three regimes of the earnings–road traffic relationship will characterise the mid-term future? The most recent empirical data (during the 2008 to 2013 period) shows a 1:1 relationship between [falling] real wages and per-capita traffic levels, but as noted previously there have been periods when this relationship has been consistently stronger (a ratio of approximately 2:1 between 1949 and 1989, when annualised growth rates are compared) and others when it has been weaker for sustained periods (approximately 1:3 between 1990 and 2007). Regardless of the extent of economic growth in coming decades, the strength of the relationship between economic activity and traffic will be a key determinant of the future trajectory of traffic levels.

A related issue is the distribution of future income. There is evidence that since the 1990s income in GB has become more concentrated in upper-income groups, such that *average* incomes have risen faster than *median* incomes. Polzin (2013) notes a similar observation in the United States and suggests it may be playing a role in mobility patterns there. Of particular note is that HM Revenue & Customs (HMRC) is currently predicting that income inequality in Britain will increase in future, as investment income is forecast to rise faster than wages in the medium term (OBR, 2014).

Moving from the macro-scale of the overall economy to the level of individual demographic groups, one of the most striking trends of recent years has been the accumulation of ample evidence – both in Britain and peer high-income societies – that young people (especially young men) own and drive cars substantially less than earlier generations did at the same age (Le Vine & Jones, 2012; Kuhnimhof et al., 2012). In 2005/7 (prior to the onset of the 2008 recession), the average British man in his 20s drove fully 30% fewer miles than his counterpart did a decade earlier; it is not hyperbole to state plainly that this decrease is without historic parallel.

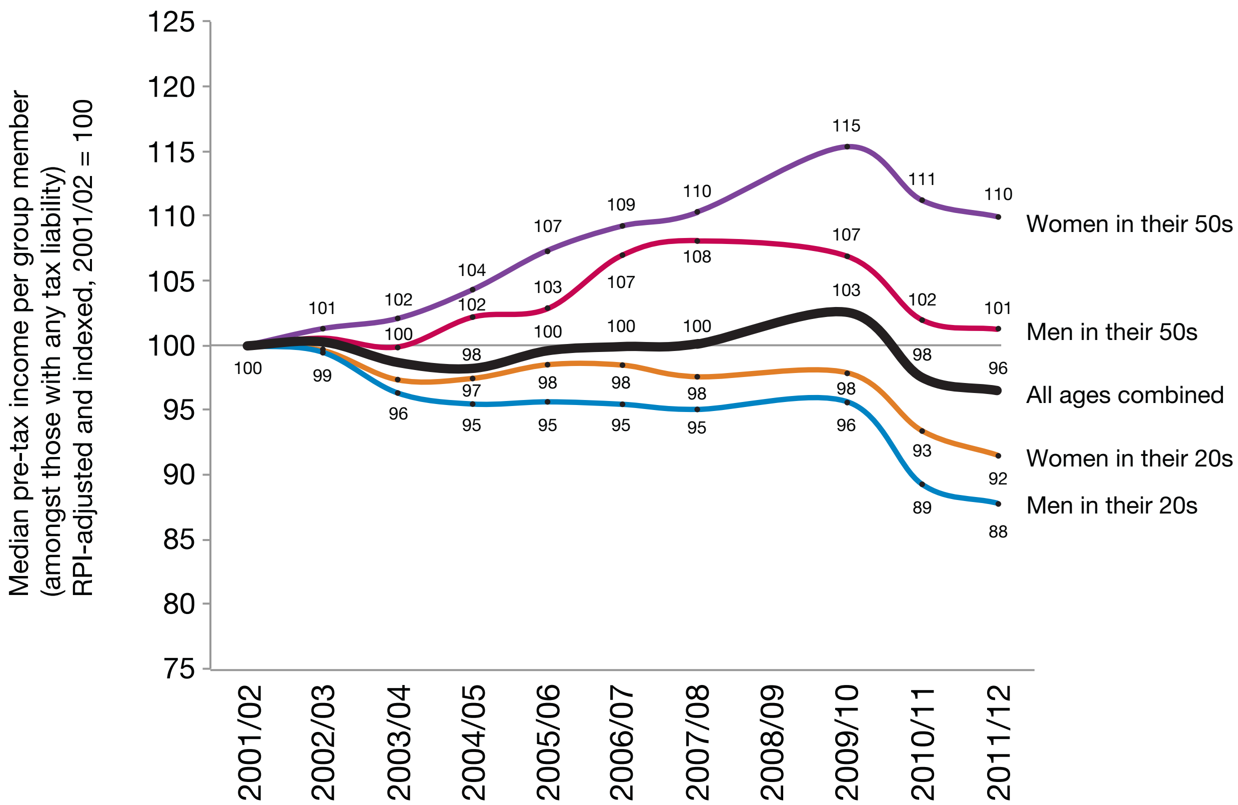
Much interest by researchers into young adults' recent mobility trends has focused on driving licence acquisition; the long-term increasing trend in young adults' licence-holding unexpectedly reversed in the 1990s, and in the 2010s it remains far below the peak rate seen in the mid-1990s. In 1995/7, 43% of Britons aged 17–20 held a full driving licence; this rate decreased to 31% in 2005 and 30% in 2013 (DfT, 2014e). Recent research by Berrington & Mikolai (2014) shows that there appears to be a wide set of contributing factors, including deferred life-course transitions in early adulthood (leaving the parental home, financial independence, marriage, home ownership and child-rearing), increased participation in higher education, and young adults residing in dense urban areas to a larger extent than earlier cohorts.

Some observers suggest that there may also be attitudinal shifts among adults – with structural changes in the perceived desirability of cars vis-à-vis other forms of transport (cycling, public transport and so on). To date, however, no authoritative assessment of the relative contribution of the various candidate factors has been put forward, nor has the direction of causality of the hypothesised mechanisms been rigorously established. While some candidate hypotheses can be eliminated (e.g. empirical evidence shows that young adults are not becoming more environmentally sensitive; cf. Le Vine et al., 2015), much remains to be done to understand properly what has happened.

Despite the uncertainties regarding lifestyle changes, two particular aspects of the changing life experience of being a young adult (and particularly a young man) have gone under-reported. The first is that economic activity has been shifting towards older age groups, to the extent that among young adults there has been no economic growth since the turn of the millennium (see Figure 3.5). It can also be seen that this has been more pronounced for young men. In other words, the sharpest drop in car use has happened among the age-gender group that has experienced the largest and most sustained decrease in earnings power. At the other end of the age spectrum, Britons are living long lives and are increasingly economically active through and into pensionable age. It is these older demographic groups that are also experiencing the most rapid growth in car use.

The second of these under-appreciated aspects of the changing life experience is that young adults face higher barriers to driving than earlier generations did. Motor insurance costs have increased rapidly in the 2000s, such that for a teenager a year's insurance costs can easily exceed the cost of purchasing a second-hand car. Acquiring a driving licence is also an expensive endeavour for the current generation of young adults (the 'Millennials'); the most recent study of the matter (in the mid-2000s) found that the average newly licenced driver received 47 hours of paid driving tuition prior to passing the test (which at a rate of £20 per hour clocks in near £1,000) (Wells et al., 2008). In 2002, one of every 1,202 workers in Britain was a driving instructor; in 2011, this rate was one per just 727 (authors' analysis of the *Labour Force Survey*). The key message is that structural price changes continue to impact on personal mobility, but that in recent years some important changes have been felt primarily by specific demographic groups. This phenomenon is not limited to young adults; reforms to company car taxation policy (which have manifested themselves as price changes) have affected middle-aged men the most, with their driving mileage in company cars having shifted onto the rail network (between 1995–7 and 2005–7) at very approximately a rate of 4:1 (Le Vine & Jones, 2012). It may be that there have been shifts in attitudes that explain recent patterns of urban mobility, but it is certainly the case that the basic constraints of incomes and prices are having impacts in ways that at first glance can be misinterpreted.

Figure 3.5: Trend from 2001/02 in median pre-tax income for selected age-gender groups



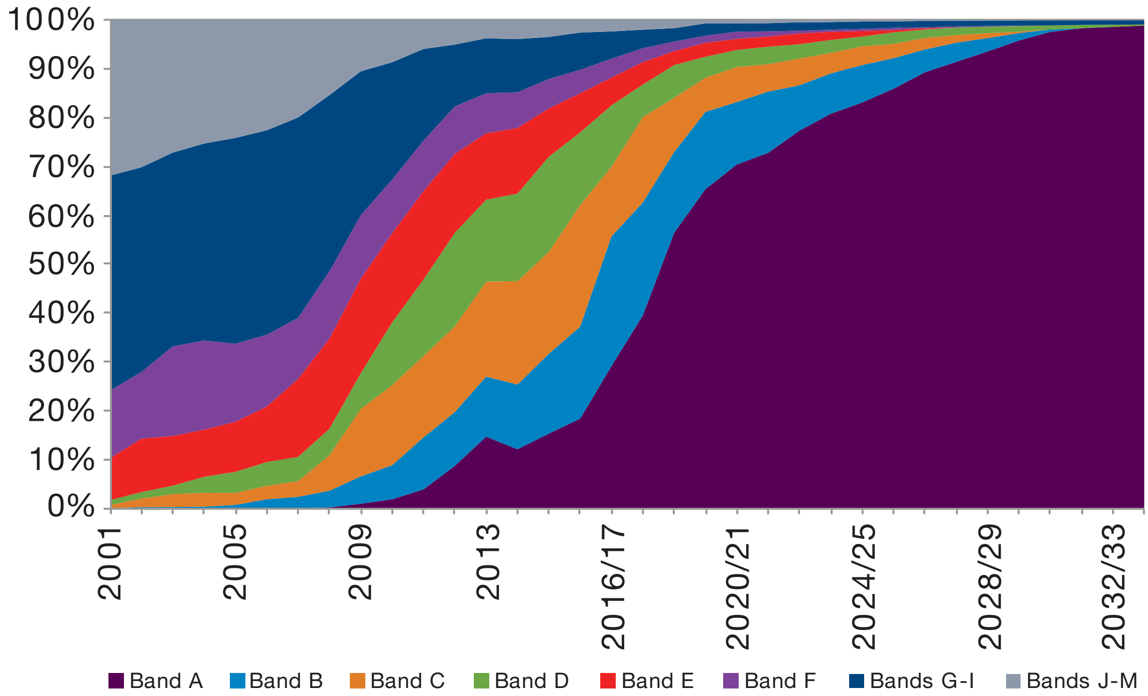
Source: Authors' analysis of HMRC's Survey of Personal Incomes (HMRC, 2014)

3 Technological trends

There has been much speculation regarding the impacts that recent technological developments have had both on applications of new technologies within the transport sector and on wider changes that impact indirectly on transport (e.g. progress in sensors, processors and data-storage capacity). Figure 3.6 shows that the Driver and Vehicle Licensing Agency's

(DVLA) current official projections are for rapid increases in the fuel efficiency of Britain's car parc such that by the late 2010s half of registered cars emit fewer than 100 CO_2 g/km, with further sustained increases through the 2020s.

Figure 3.6: Distribution of Vehicle Excise Duty bands for Britain's projected car parc



Source: OBR (2014: Chart 4.18)

As noted previously, many observers believe that the strong growth in van traffic in recent decades relates to activities such as online shopping that are enabled by new technologies. Other less visible changes have clearly also contributed, such as increasingly sophisticated and time-sensitive logistics systems that rely heavily on real-time data streams. Additive manufacturing has been highlighted as a technology with the potential to drive further radical change in logistics patterns.

There is presently a vigorous scholarly debate regarding the overall effect of developments in ICT on road traffic levels. On one side of the debate it is argued that an increasingly large set of activities that once required face-to-face contact are now routinely performed virtually, and that virtual activities will become more pervasive in coming years as the required technologies mature. Proponents of the opposing view (led by Professor Emerita Pat Mokhtarian of Georgia Tech) point to the concurrent growth over a long-term timescale in both travel demand and telecommunications. The debate remains quite active, with new findings continuing to emerge. A particularly relevant question is whether ICT itself will continue to evolve at the pace seen in recent years, or whether fundamental limits on further technological advancement will be reached (e.g. limits on data-network capacity and heat-dissipation from processors).

Technological development has over time reduced the labour input required in many sectors of the economy, with structural implications for labour markets (specifically the relative demand for unskilled versus skilled labour). One of the most intriguing recent developments in the automotive sector itself is the increasing automation of the driving experience, with some (not all) informed observers believing that the human 'driver' in manual control of a vehicle's operation may become obsolete in the next several decades. Whether or not this vision becomes a reality remains to be seen, and will depend both on 'pure' technological developments and on how society incorporates them into the regulatory framework that governs behaviour on the road network. In addition to the great uncertainty regarding the trajectory of vehicle-automation technology, the impacts on urban mobility are very poorly understood and will depend on both market acceptance and public policy decisions. There is a general consensus, however, that algorithmic vehicle operation during emergency manoeuvres is likely to be better than human driving behaviour, with positive implications for road safety. This could have important consequences for road safety, which has tended to improve (as measured in fatalities from road crashes) in recent years.

4 Public policy

Public policy towards transport is unavoidably subject to conflicting pressures, as the various desirable outcomes (e.g. economic opportunities and physical exercise) and undesirable outcomes (e.g. crashes and community severance) associated with the transport system cannot all be optimised simultaneously. How governments (whether local authority level, central government or supranational) respond to competing prerogatives depends on value judgements of individual policymakers, which will vary when policymakers themselves change (such as after an election or a ministerial reshuffle) or even without personnel turn-over when there is a change in circumstances.

Policy is unique in comparison to economic trends and technological developments, as it depends on a relatively small number of policymakers making a relatively small number of discrete decisions. By contrast, economic and technological trends are *decentralised*, arising from the interactions of many millions of individuals' choices and actions.

There is also no single 'transport policy' that governs the full range of public sector actions at any point in time. Central government sets the rate of fuel duty and regulates rail fares, for example, but bus fares in London (where more than half of bus journeys in Britain take place) are set at the discretion of the mayor. Central government is also not directly responsible for administering parking policy, which can greatly affect both how and how often people travel to a location for discretionary activities. Local authorities are much more directly involved in parking provision, as well as land development actions that shape future travel demand. Local authorities are therefore where much transport policy as it is felt by individual urban travellers is made.

Policy to limit carbon emissions from transport activity has had a major impact in Britain, with dieselisation being one particularly potent mechanism that has structurally affected the car parc. While this has led to downward pressure on carbon emissions by Britain's transport sector, it has led to increased emissions of local air pollutants (e.g. particulates). Local air quality is quickly rising up the public policy agenda, and it remains to be seen how future transport policy will reconcile these competing environmental challenges that operate at different spatial scales. It is possible that vehicle technology and consumer behaviour may combine to spare policymakers from having to take difficult decisions, but this is far from assured.

Transport policy manifests itself in other ways as well. It has been calculated that the street network's capacity for private motorised traffic has since 1996 been reduced by 30% in central London, 15% in the rest of Inner London and 5% in Outer London (TfL, 2013a). This largely reflects the reallocation of space towards non-private motorised forms of travel (e.g. cycling, bus movements and walking). These changes highlight the 'plasticity' of the physical transport network even within fixed right-of-way lines; the important questions for the future are whether such policy trends have run their course, or whether they will intensify or widen to other areas. Such choices are of course deeply political; an item currently on the public agenda is the proposal made in early autumn 2014 for redesigning streets through London to provide new Dutch-style, segregated, north–south and east–west cycle ways.

Shared mobility is another policy-sensitive aspect of urban mobility. London's system of casual-use 'Boris Bikes' is funded and managed by the public sector. Car clubs – shared-use cars available for hire on an hourly basis – are generally delivered in Britain by the private sector, but in many cases councils provide dedicated on-street parking space. Flexible shared-use cars (for spontaneous by-the-minute, one-way usage) operate in an increasing number of urban areas globally; London is by far the most attractive market in Britain for these services, but the fragmentation of local government makes it challenging to provide the required privileged access to on-street space with suitable geographic coverage.

Beyond the niche of shared-mobility systems, governance of the transport sector will have broad consequences for urban mobility. While the success of privatising British Rail into the rail industry as we know it today remains a matter of public debate, it is indisputable that rail privatisation has coincided with a period of very robust growth in rail patronage – one that has bucked the historic downward trend during periods of recession. More recently, the governance of road transport in Britain has been the subject of serious discussion, with specific proposals that would provide greater autonomy from central government and the ability to plan multi-year investments in the road network more strategically.

5 Foreseeable challenges for urban regions

Britain's diverse urban regions face a similarly disparate set of future challenges. Some are common: all local authorities are, for example, limited in their room to manoeuvre by central government regulations as well as by cumbersome procurement processes. There is a general mismatch between the pace of events in the private sector and in town halls. But many of these challenges vary between cities. As discussed previously, the densest urban areas are forecast to have the most rapid population growth in the coming decades, which implies that the provision of adequate housing will remain a first-tier issue for some time in the subset of cities facing these pressures.

Replacement and upgrading of aging infrastructure are challenges for urban areas across Britain; this problem is exacerbated in rapidly growing urban areas by the difficulty of undertaking the required works while accommodating increasing demands. Indeed, the TfL estimates that road congestion imposes £4 billion in wasted costs on the capital annually, of which more than a third (36%) is attributable to roadworks (TfL, 2013b; Mayor of London, 2010).

Much has been said regarding the future of both the out-of-town retail park and the traditional High Street. Ease of access is a key determinant of economic viability for both of these archetypal shopping environments. Cities face difficult trade-offs: restricting car access to town centres can help meet targets for reducing car use, but this may come at the expense of some loss of economic activity. Furthermore, cities must now contend with the growth in online shopping activity, which is increasingly putting pressure on all ‘bricks-and-mortar’ retail – whether in or out of town.

Unlike national government, cities face the challenge of delivering economic growth and a high standard of quality of life within the constraint of tightly circumscribed autonomy to determine taxation and spending policy. Central government freely recognises that “the UK’s local government finance system is one of the most centralised in the world” (DCLG, 2013). The challenge for urban areas is that central government’s fiscal position is forecast to come under increasing strain over time. Current projections are that public debt will decrease until the mid-2030s, but will then proceed to grow (OBR, 2014). If this occurs, one can reasonably expect this additional financial pressure to be passed down the public sector food chain in the form of reduced levels of grants to local authorities.

Cities will also continue to be on the front lines of conflicting pressures between expectations from higher levels of government on the one hand and from their citizens on the other. The transport domain is rife with such conflicts: for example, discouragement of car use motivated by policy goals of various sorts can be in tension with the day-to-day mobility demands of the majority of urban residents and workers.

Finally, Britain’s cities will in future need to accommodate an increasingly diverse population. Rapid growth in the number of pension-age residents will strain social service budgets, at the same time as historically large numbers of international migrants will tend to concentrate in Britain’s larger cities. Examples of these demographic changes affecting urban mobility are the debate over subsidized public transport usage by pensioners, and the relatively low prevalence of driving licence holding among international migrants.

6 Black swans

The discussion to this point has focused on large-scale trends that may affect urban mobility in future. One must, however, also be cognisant of 'black swans' – events that appear to be unlikely to happen but if they do occur would have large impacts.

Great care, consideration and deliberation underpin the economic and demographic forecasts noted earlier. However, the depth of the 2008 recession and subsequent lacklustre recovery were in general not well predicted in advance. A return to the long-term trend of economic growth as currently forecast by government may well take place, but this is not a foregone conclusion. Though unlikely, one can also imagine other economic disruptions such as a bout of sustained inflation or the failure to pay pensions in line with current expectations. Demographic forecasts are also characterised by substantial uncertainty; in 1994, government was forecasting that the UK's population would reach a 'peak' and then begin to decrease in the 2020s; the current forecast, however, is for population growth at faster-than-historic rates as far into the future as one cares to look (past the 2070s). If either (or both) economic activity or demographics trend along unexpected trajectories, there would be major implications for urban mobility.

Energy availability and demand are other important unknowns. It is not difficult to imagine scenarios that could result in an energy 'shock' in future, but the opposite is also plausible. New technologies may come on-stream that lower the costs of providing energy to consumers, or that enable end users to consume energy more efficiently. An underappreciated impact of large-scale electrification of the car parc would be a structural reduction in the marginal costs of motoring, with potentially a 'rebound effect' of increased traffic levels.

Beyond energy, wider technological developments must not be discounted. It is likely that ICT will advance incrementally for the foreseeable future, but we do not know whether there will also be step changes in technological developments either within the transport sector or in other inter-related aspects of human activity (e.g. tele-presence).

Disasters – both man-made and natural – will also surely occur, though the precise circumstances, how severe the disruption will be and how society will react cannot be known in advance. New York City, for example, was struck by the 11 September terrorist attacks in 2001, and eleven years later by Hurricane Sandy, which flooded subway tunnels and flattened entire neighbourhoods, causing an estimated £40 billion ($65 billion) in damage. While it is clear how mobility (most notably air travel) has changed since 2001, Hurricane Sandy's consequences have yet to fully take shape.

Beyond their immediate disruption, disasters provide an impetus for radical, long-term changes that otherwise would not be under consideration. For example, in the weeks following the 11 September attacks, private car access into Manhattan was restricted to cars with three or more occupants. This policy was subsequently rescinded, though there was serious discussion of keeping it in effect indefinitely.

Finally, governments may conceivably undertake major policy reversals that could impact on mobility. Consequential decisions include the possibility of leaving the European Union (with likely economic implications), new directions in environmental policy, the fiscal settlement between central governments and local authorities, changes to the benefits and taxation regimes and new planning guidance to local authorities.

This short paper highlights what is currently known regarding recent patterns of urban mobility, and a selection of the important determinants for patterns in the coming several decades. While there are a great many unknowns regarding the future of urban mobility, there can be little doubt that its unfolding will bring together both traditional 'drivers' of mobility and unforeseen surprises along the way. It will certainly make for interesting viewing.

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4. The then and now of urban areas

– by David Bayliss

1 Introduction

This paper looks back to urban Britain at the onset of mass motorisation, when the main ways of getting around were changing from public transport, walking and cycling to travel by car. It looks at the early proposed policy responses to the problems and the opportunities that these changes brought and then examines key features of the actual changes that ensued over the intervening years. In particular, the effectiveness of regulation, pricing, technology, infrastructure development, governance and financing in tackling the problems of urban mobility are examined along with the implications that this past experience has for current and future practice.

2 Changing land use and travel patterns

Taking 1960 as the principal reference point, the UK had yet to join the Common Market, the Berlin Wall had not been built and man had not yet ventured into space. Britain still had the death penalty, blacks and whites remained segregated in several American states and concerns about the effects of smoking on health were still to be voiced. Also, in 1960, British Railways, the London Transport Executive, the canals, docks, ports and road haulage were nationalised and under the control of the British Transport Commission. By 1960, there were almost 5 million cars and 8½ million road vehicles in total (DfT, 2014a), resulting in a near trebling of traffic since the end of the Second World War (DfT, 2014b), and almost seven thousand people died on the roads (DfT, 2014c). In 1960, almost one quarter of households had a car. By 2014, three quarters of households own one or more cars (DfT, 2012d), the car parc is now 29.4 million and urban road traffic has grown from 37 billion vehicle miles (vms) to more than 120 billion (DfT, 2014e) (0.93 million vms per capita per year to 2.35 million vms per capita per year, including traffic on motorways in built-up areas). By 1960, the use of many residential streets as play and meeting areas was already in decline.

In 1960, Britain was already an urbanised country with the percentage of people living in towns and cities approaching 80% (Jones, 1970) – not much less than today. However, urban form was starting to change, with industrial activity beginning to decline and service industries to grow. In the 1960s, more than 70% of new retail space was in traditional town centres; by 2000, this had fallen to 25%, but has recovered since to about 30% currently (DCLG, 2009). Although most Britons live in towns and cities, only around 6% of Britain is urban (DCLG, 2007) and the average encroachment into agricultural land has been of the order of 0.1% per year (Best & Champion, 2007). Between 1960 and 2014, the population of Britain grew from 51.2 million (The Economist, 1997) to 62 million (ONS, 2014a). Together with the small increase in urbanisation, this means that the urban population has grown by around 11 million from around 40 million to 51 million.

Rising car ownership and changing lifestyles have taken their toll on public transport use. Local bus journeys fell by 10% during the 1950s and were to halve by the mid-1970s (DfT, 2014f); in 2012/13 at 35% of the 1950 figure. The bus and coach share of personal travel fell even faster: from 43% in 1950, to 28% in 1960, to 14% in 1975 and was at 5% in 2012/13 (DfT, 2014g). By 1962, all but one tramway system had been closed, and in 1972 the last trolleybus system closed (DfT, 2014h).

Ridership on the London Underground remained steady during the 1950s and 1960s, but then gradually fell away to 74% of its 1960 level by 1982. Since then, triggered by, among other things, the introduction of integrated zonal travel cards and later the Oyster card, it has increased two and a half fold. Taking all local public transport together, ridership has reduced from 14 billion journeys in 1960 to 6.6 billion in 2012/13. National rail travel has doubled since the mid-1990s – but after forty-five years of fairly limited increases and decreases (Ibid.). Of course, much of this is between, rather than within, urban areas. In 2013, 48% of national rail travel was in London and the South East, 19% on regional and 33% on intercity (ORR, 2014a).

Car travel has grown by 363% since 1960, rapidly up until 1990 and more slowly since then. Despite a fall since the 2008 recession, car traffic has started to grow again – albeit slowly (DfT, 2014g). Car travel typically provides for two thirds of trips and 80% of travel in urban areas (DfT, 2014i).

Cycling halved between 1950 (when it formed 10% of personal travel) and 1960, and it continued to decline through the 1960s but has been fairly stable since – at about 1% of travel (DfT, 2014g) and 1⅔% of trips (DfT, 2014j). Of this, three quarters is in urban areas (DfT, 2014k). Cycling is more common as a recreational activity than for transportation, so on average its contribution to functional urban mobility is limited. However, there are marked variations in cycling levels. In Cambridge, 58% of people cycle at least once a month, while in Oldham the figure is less than 5% (DfT, 2014l).

Currently around 22% of journeys are by foot. Since 1972/3, the proportion of journeys of less than one mile in length (where walking is most common) has fallen from 38% to 20%. Between 1971 and 1991, the percentage of people walking to work fell from 22% to 13%, so the proportion of walk journeys has fallen significantly over the last three decades (DfT, 2014j). However, the reductions in non-car travel were dwarfed by the overall increase in mobility from 3,450 miles per capita in 1960 to 7,800 in 2013 (DfT, 2014i).

3 Initial policy responses

By 1960, the inter-urban motorway programme was underway and growing urban traffic congestion and falling public transport ridership were serious policy issues; and a number of studies were carried out to help shape public policy in this area. The most important of these was *Traffic in Towns* – popularly known as the Buchanan Report – published in 1963. This addressed the misfit between the layout of urban areas and the demands of growing motorisation.

Buchanan concludes that there were absolute limits to the amount of traffic that could be accepted in towns and, within these, the amount of traffic that could be reasonably accommodated depended on the physical changes that society was prepared to accept and pay for. Few of the then current urban development plans, he concludes, faced up adequately to the problems of traffic and transport.

The study looked at towns of various sizes and what could be done to reconcile the conflicts between the demand for car use and the pressures on the built environment. It concluded that, while changes had something to offer, these would be slow in coming and offer limited short-term help. In all but the smallest towns, accommodating full mobility by car was impossible and coordinated public transport would be needed and should be a statutory requirement of the planning system.

Traffic in Towns proposed that these plans should include control of the amount, location of and charges for parking, good cheap public transport and aesthetic expansion of primary road networks to provide for increases in traffic. They should also permit the development of 'environmental areas' by the use of environmental management. In the centres of larger towns, the accommodation of traffic would need comprehensive redevelopment. Among the recommendations for further work was to investigate the application of cost–benefit analysis in urban transport.

Hot on the heels of the Buchanan Report came the Smeed Report (MoT, 1964), which examined the case for, and practicality of, road pricing. This concluded that direct variable road pricing was the best way of controlling congestion and would produce annual benefits of between £2 billion and £3 billion (at today's prices but early 1960s levels of congestion) and that there were a number of feasible technologies for implementing this.

Over the years since 1960 there have been a number of government reports on the transport problem, but few effective proposals for dealing with urban congestion and mobility resulted from these. Most government proposals such as those in *Roads for Prosperity* (DfT, 1989), the Multi-Modal studies (Marsden, 2002) and the Eddington Study (Eddington, 2006) focused on the inter-urban road network.

One of the few serious attempts to tackle the urban transport problem was set out in the *Ten Year Plan* (TYP) (DETR, 2000). It is difficult to establish how much proposed in the *TYP* has been implemented, as many of the ideas were expressed in general terms. However, many of the London proposals have been implemented (albeit often later than planned), with the notable exception of an East Thames river crossing. For other urban areas, the picture is more mixed, with aspirations to build new rapid transit lines, increase bus usage and integrated information, booking and ticketing services and trebling the use of bicycles either only partly achieved or failed.

Another important development in the 1960s was the development of more sophisticated ways of forecasting future traffic growth in ways that reflected changes in population, employment, income, land use and the transport system. Land use/transportation studies were carried out in London (FFWSA, 1968) and the other major metropolitan areas during the 1960s. These provided forecasts of travel demand twenty or so years ahead and evaluated a range of policies and programmes for addressing these. Typically, these contained ambitious plans for improving both roads and public transport, but with the main emphasis being on roads; in London, they also included the need for traffic restraint. The prospects of the costly infrastructure programmes these posited stimulated questions as to whether such expenditure would be worthwhile – and (echoing Buchanan) pointed to the need for some form of systematic way of estimating value for money. In 1960, a study (Coburn *et al.*, 1960) into the economics of constructing the M1 between Watford and Rugby was carried out, and in 1962 the proposed Victoria Underground Line was also the subject of a cost-benefit analysis (Foster & Beesley, 1963). This approach was further developed in the London Transportation study to evaluate whole road and public transport networks – the use of cost-benefit analysis in urban transport had arrived.

The worsening financial circumstance of public transport in the 1960s prompted government to step in, to try and reduce costs and provide financial support. The 'Beeching Report' (British Railways Board, 1964) recommended that the railways should be adapted to focus on those routes and the markets they served best and that they should close down routes that were so lightly loaded as to have no chance of paying their way. Beeching pointed out that one third of the route network carried less than 1% of passenger traffic and receipts; and 40% of the freight network carried less than 3% of freight traffic. As a result, British Rail's route mileage was reduced from seventeen thousand in 1963 to less than twelve thousand in 1970, and the number of passenger stations from 4,300 to 2,420. The 1960s also saw the start of external funding for the railways, initially on an *ad hoc* basis and subsequently through a series of statutory grant regimes.

Buses were also facing financial difficulties in the 1960s, and a series of grants starting with Fuel Duty Rebate was followed by New Bus Grant and Infrastructure Grant, Rural Bus Grant, Concessionary Fares Grant and direct operator subsidies. These were rationalised into a Transport Supplementary Grant scheme in 1974, and from £33 million in aid in 1969/70 (DoE, 1976) support for local bus travel mushroomed to more than £1 billion in 1984/5 (DoE, 1997a) and reached £2.7 billion in 2012/13[1]. Non-local buses have been operating as commercial services for many years, and they provide a wide range of services from local coach tours to inter-urban scheduled services. Their use doubled in the twenty years following the development of the motorway network, and they are currently responsible for 10% of personal travel. However, the impact of non-local buses on urban mobility is limited, and their effects on urban traffic minimal.

The range of interventions that policymakers have (and have not) used to improve urban mobility includes: regulation; pricing; infrastructure; technology; and governance and funding.

4 Regulation

Regulation has become a vital tool in aiding mobility and minimising the harmful effects of transport operations. It takes many forms including the regulation of transport technologies, operations and transport markets. Some forms of regulation of road use have long existed, and since the growth of motor traffic these have increased. Today, the extent of regulation is evident with at least 4.6 million road signs in England – more than double the number of twenty years earlier (DfT, 2014n). Economic regulation has also changed since 1960, when most public transport services were in the ownership or control of central and local government, whereas today most public transportation is provided by private operators.

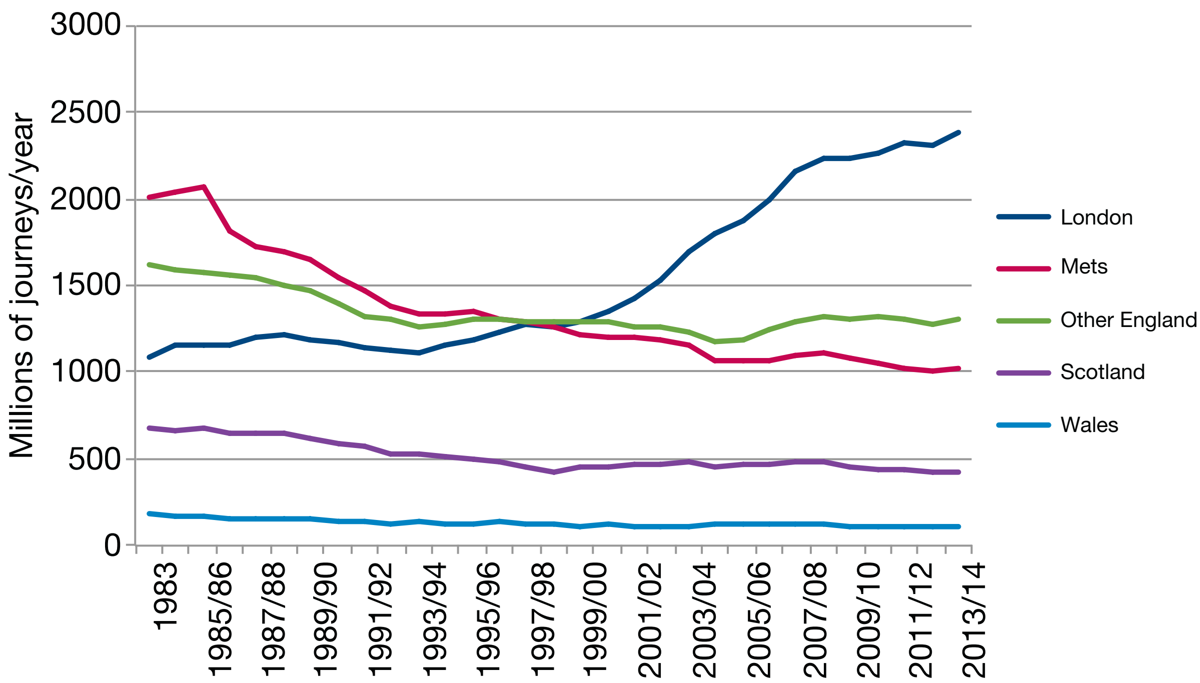
Safety regulations have been one of the great success stories, and they account in large part (but not entirely as vehicles and road designers have also played their part) for the substantial reduction in the numbers of deaths and injuries on

1 DfT (2014m), Transport Scotland (2014) & Welsh Government (2014a).

roads. Since 1950, the number of people killed and seriously injured (KSIs) has fallen from 54,000 to 21,232 in 2013 (DfT, 2014o), despite a nine fold increase in traffic (DfT, 2014p), and the casualty rate (71% of casualties are in urban areas) from 4,440 per billion vehicle miles to 450. Vehicle construction and use, seat belts, drink and drug driving and driver and vehicle testing regulations are just a few of the government initiatives that have contributed to this improvement.

By the 1970s, most urban bus services were provided by municipal operators or subsidiaries of the National Bus Company, as falling ridership made many private operations unprofitable. The costs to taxpayers and ratepayers were rising year by year, despite the switch to one-person operations following the introduction of the New Bus Grant in 1969. The 1980 Transport Act opened access to private bus operators in trial areas, and the 1985 Transport Act deregulated bus operations outside London as well as privatised the National Bus Company. Financial support was made equally available to all local bus operators, with local authorities subsidising 'socially necessary' services, and publicly owned bus companies having to operate on a commercial basis.

Figure 4.1: Passenger journeys on local bus services by metropolitan area status and country 1983–2013/14.



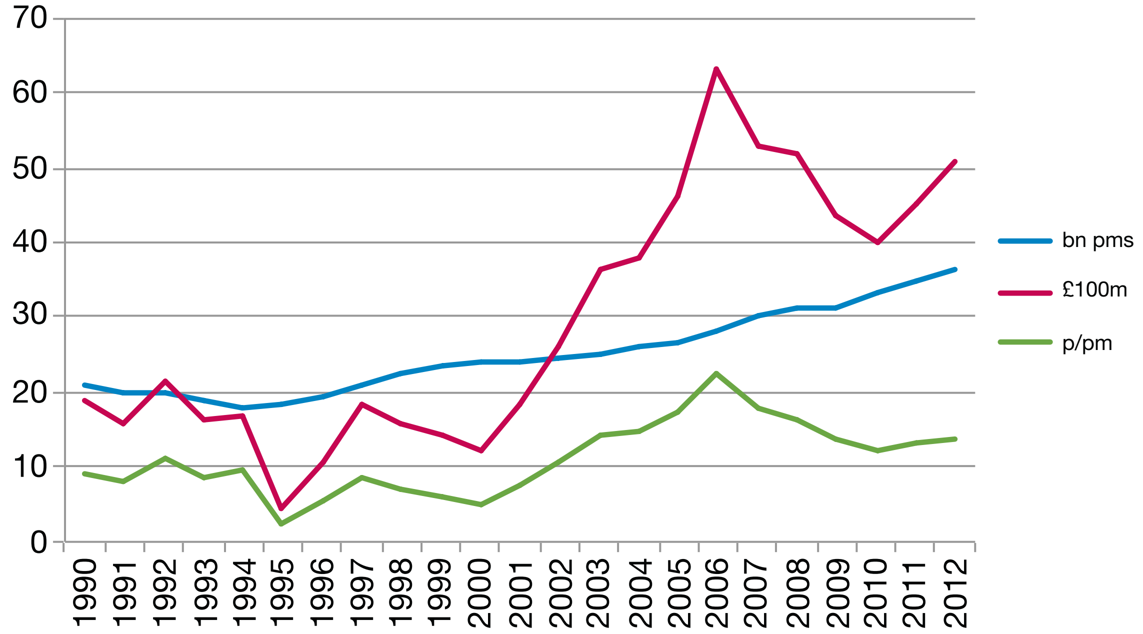
Source: DfT (2014q)

In London, bus services remained under the control of London Transport as part of an integrated fares-and-service regime, but they were progressively tendered out and eventually all London Bus operations were sold off to private sector owners.

As is evident from Figure 4.1 the contrast in ridership trends is significant. In the less urban English shire counties, Scotland and Wales, deregulation had little effect on the steady fall in passenger numbers, but in the English metropolitan areas the reduction in bus use, in the decade following deregulation in 1986 of 38%, approached twice that in the preceding decade – while in London bus ridership grew. Between 1986 and 1996, financial support for London's buses fell by 80%, compared with 70% outside, and was less than half of that in the Metropolitan county councils (Mets) despite carrying 93% as many journeys. Bus use in London has continued to grow and in 2012/13 surpassed that in the rest of England (DfT, 2014q). While the case for stronger integration of bus operations outside London under local transport authority control remains a contentious issue, the evidence points strongly to there being a case for this in the larger towns and cities.

Following nationalisation in 1948, British Railways remained in public ownership until 1996. There was no explicit regulation as the government, through a variety of means including appointment of the British Railways Board and scrutiny of revenue plans and capital programmes, had effective oversight of British Railways' activities. Following privatisation, this altered and, among many other changes, a Rail Regulator was established to oversee the economic performance of Railtrack and its successor Network Rail as infrastructure operator; and to ensure fair access arrangements, to protect consumer interests and to ensure high standards of safety. At the same time, initially through a franchise director but now through the DfT, the government had to make explicit choices about services, capacity, quality and user charges, and this has developed into the current planning regimes with five-yearly High Level Output Specification and Statement of Funds Available.

Figure 4.2: National rail ridership and subsidy trends, 1990–2013[2]



Sources: ORR (2012), ORR (2014a, 2014b)

The combination of clear objectives for, and funding of, the passenger railway coupled with competition for franchises and tight regulation has been a major factor in the large increase in ridership over the last twenty years. It has also resulted in a substantial increase in financial support for the railways but a less marked rise in the support rate.

Regulation has been important in reducing the environmental impacts of road transport. The introduction of increasingly stringent emission standards, in particular the series of euro standards starting in 1993, and the replacement of older 'dirtier' vehicles saw continuing progress in reducing emissions, despite traffic growth. Today, CO emissions are less than a tenth their 1980 levels, NO_x emissions are down 30%, SO_2 down 75% and lead has all but been eliminated (DTLR, 2001, DfT, 2014r). However, growing evidence of the harmful effects of some of these emissions – principally nitrous oxides and fine particulates – has prompted the introduction of air quality standards which are exceeded frequently in many British towns and cities. CO_2 emissions from domestic transport grew by a quarter between 1970 and 1990, but following measures to contain them these are now a little below their 1990 levels despite an increase in road traffic of 19%.

To help combat concerns about traffic noise, EU noise emission standards have been progressively introduced since 1970. Car limits have been reduced from 82 dB(A)[3] to 74 dB(A) currently and lorries from 92 dB(A) to 80 dB(A)

2 Billion passenger miles (bn pms), Hundreds of millions of pounds (£100bn) and pence per passenger mile (p/pm).

3 A-weighted decibels, abbreviated dB(A) are an expression of the relative loudness of sounds in air as perceived by the human ear.

with a further reduction of 4 dB(A) for cars and 2 dB(A) for lorries over the forthcoming decade.

Freight operations had been strongly regulated during and following the Second World War, with the nationalisation of road haulage and the establishment of British Road Services in 1948; but twenty years later these were deregulated by the 1968 Transport Act. This change opened up entry into road haulage and removed protection of certain traffics on the railways. Overall, it reduced goods transport costs and shrunk the concentration of freight collection and distributions from central railway stations while conventional van traffic grew. Deregulation of freight undoubtedly contributed to a shift from rail to road and, coupled with the decline in coal and steel production and the shift from manufacturing to service activities, helped stimulate the 4.6 fold growth in van traffic from 10% of all road use in 1970 to 14% today (DfT, 2014b).

5 Pricing

Pricing is potentially a powerful tool of transport policy, and it has been used over many years to manage demand and raise revenue. The types of pricing mechanisms most commonly adopted in urban transport are parking charges, public transport fares and direct road use charges. In the late 1950s, on-street parking meters (30p an hour) were introduced to manage demand for kerbside parking in central London. By 1966, there were more than 14,000 of these; and other cities were following suit.

The overall effectiveness of parking pricing is limited by the fact that only 6% of parking acts are paid for (Bates & Leibling, 2012). Even when paid for, charges are determined by commercial considerations in many off-street car parks rather than by public policy interests. Planning controls can limit the provision of additional parking in congested areas, so helping to balance traffic demand with the limited supply of road capacity. In an environment where direct use of congested roads is not charged for, this will often be the only effective way of containing car traffic and congestion, but it is very much a second best means as it has little effect on ‘through’ traffic.

Parking charges have been used widely to control the use of on-street parking in town and other activity centres. The technology has developed over the years, and modern ICT systems are increasingly used for payment and enforcement. Over the last couple of years, concerns have been expressed at the level of surpluses made by some local authorities on their parking accounts; however, where there are revenue surpluses (Leibling, 2013) these will usually have resulted from an excess of demand over supply and, provided the charging is fair and efficient, there is nothing wrong with the realisation of a surplus as long as this is applied to a legitimate transport purpose in the area.

Public transport fares are charged to help meet the costs of services, while fare differentials are used to help spread traffic from the peak into the off-peak and to generate revenue from 'slack' off-peak capacity. From time to time, the lowering of fares on public transport has been advocated to reduce car ownership and car traffic (and in some instances implemented: e.g. South Yorkshire and Greater London). While reducing fares can increase the use of public transport and create wider social benefits, the relatively low elasticity of ridership-to-fare changes means that, except for some niche sectors of the market, fare receipts fall – and car use is little affected.

Direct road-user charges are potentially the most effective way of reducing urban traffic congestion but have proven very difficult to introduce. Despite the upbeat conclusions of the Smeed Report, that road pricing was both economically worthwhile and technically feasible; it was not until 1974 that a serious study was done of a charging scheme for central London (Greater London Council, 1974). The strongly negative response to consultation on this saw its abandonment, and a watered-down scheme five years later did not even get to the public consultation stage. While the London Congestion Charge introduced in 2003 followed closely the recommendations of a study by the Government Office for London (Government Office for London, 2000), this time there was the political will and skill of Ken Livingstone – the first elected Mayor of Greater London – to secure its implementation. Undoubtedly, two factors were critical in gaining sufficient public support for the scheme: providing a generous range of exemptions and concessions; and giving a guarantee that for the first ten years of its life any surplus receipts would be spent on improving transport in the capital. Although a small road-access charging scheme was introduced in Durham (Sadler Street) in 2002, attempts to implement substantial schemes in Manchester and Edinburgh failed partly because of specific concerns about the impacts of the schemes and partly as a result of a fear that these were little more than further taxes on already overburdened motorists.

The other form of traffic restraint using a form of pricing, permitted by current legislation (Transport Act 2000), is the Workplace Parking Levy. This has been introduced in Nottingham, where an annual fee of £362 is currently charged on employers for each eligible space. In 2012/13, this raised £7.8 million, but there have been problems of increased on-street parking (The Taxpayers' Alliance, 2014). The proceeds are being used to help fund public transport improvements, but to date there is no evidence of its effects on traffic or business activity.

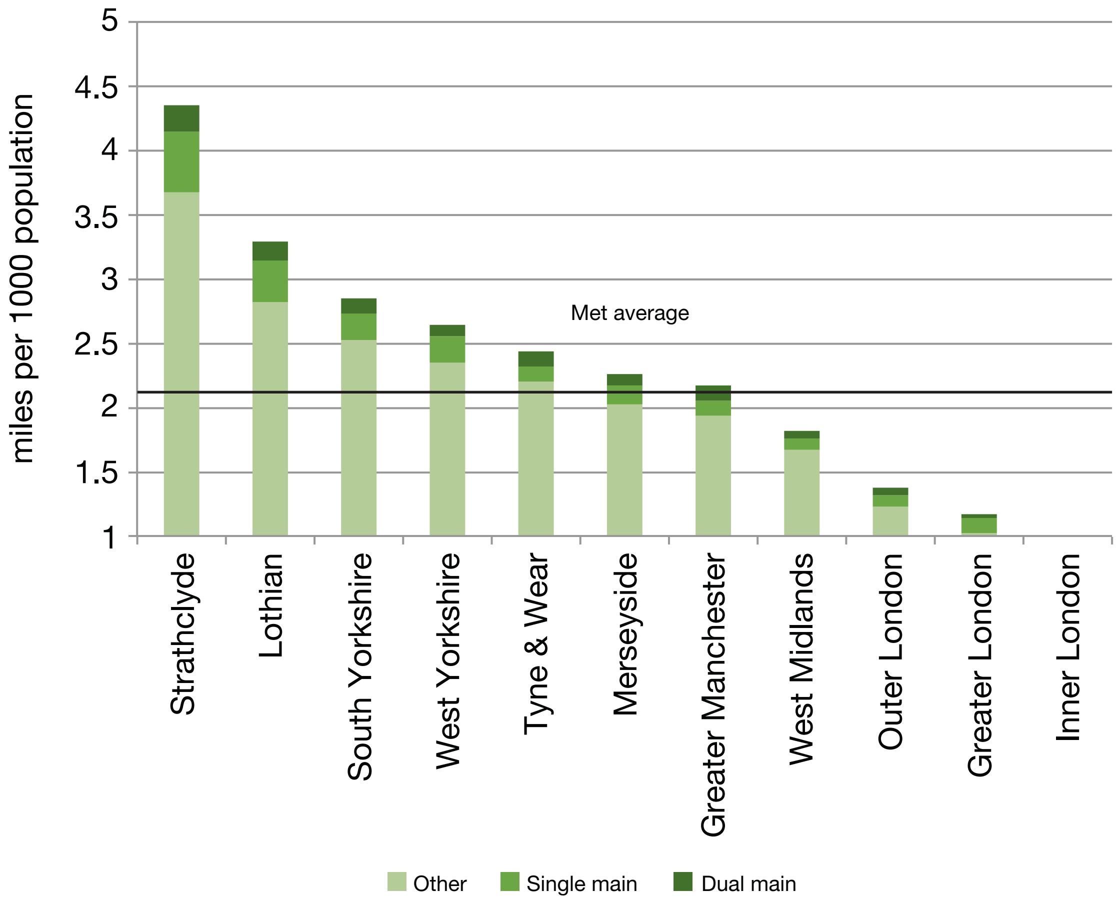
6 Infrastructure

The difficulties foreseen in the 1960s of changing the urban fabric to accommodate mass motorisation have in the event turned out, if anything, to be greater than anticipated. Some urban bypasses and ring roads have been built, but the only metropolitan area that has succeeded in achieving the provision of a substantial high-quality road traffic network has been Greater Manchester, where 45% of its traffic travels on its 106 miles of motorways compared with Greater London, with its 37½ miles carrying only 8% (DfT, 2014s). Even if London were treated as the area out to and including the M25, this would still be only around 25%.

The length of the road network has grown substantially since 1960, from 194,000 miles to 246,000 miles, but most of this expansion has been as minor roads (a 30% increase), with the major road network growing only from 28,000 miles to 31,000 miles (11%) (DfT, 2014t). This increase includes the enlargement of the motorway network, but this is located largely outside the main urban areas. It is worth noting that road provision in Britain at 4.06 miles per thousand people is less than the European Union average of 6.48, and that motorway provision is very much lower – at 37 miles per million population compared with 85 (European Commission, 2014). Although long-distance road transport has been much improved, this has brought only limited benefits to urban mobility, where traffic congestion is of the greatest concern (46% of people seeing this as a serious or very serious problem compared with only 28% in respect of motorways) (DfT, 2014u).

Using dual-carriageway roads as a crude indicator of a quality traffic road, it can be seen that, of the 88,790 miles of urban roads in Britain, only 6,887 are A-roads and just over a quarter of these A-roads are dual carriageways (DfT, 2014v). Figure 4.3 shows the variation in all roads provision between the main metropolitan areas where the average of 2.15 miles per thousand population is just over half the GB average. Strathclyde and Lothian are less urbanised than the English Metropolitan area (Mets) so it is not surprising that provision there is higher. Clearly, on this basis London is the least well provided and the smaller the English Met the better the provision. The picture for free-standing towns is not dissimilar overall, with 2.12 miles per thousand people, with larger towns having a lesser provision.

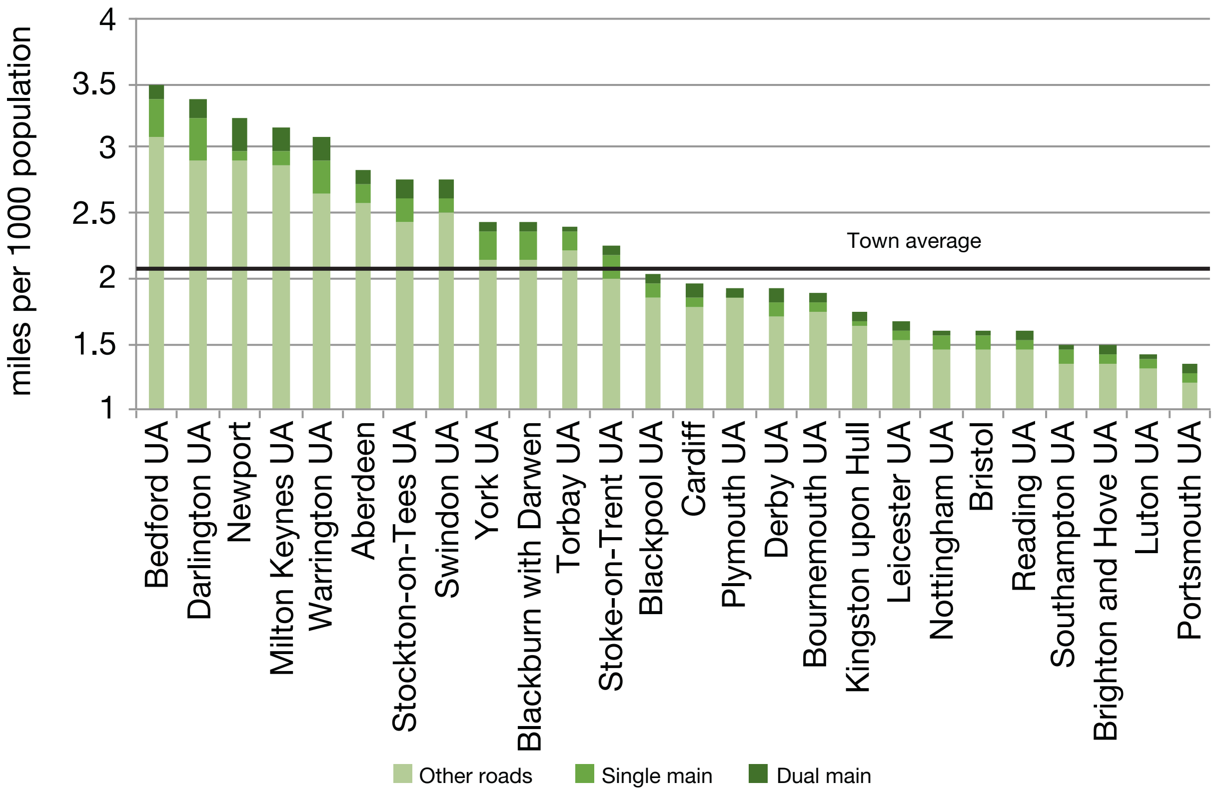
Figure 4.3: Metropolitan areas – roads provision, 2012



Source: DfT (2014s)

Dual-carriageway provision is much leaner, averaging 0.094 miles per thousand people in the Mets and 0.104 in the free-standing towns. This varies by almost an order of magnitude, with coastal towns generally faring poorly as a consequence of their peripherality; at the other extreme are those settlements that have benefited from the presence of the motorway network or from planning to accommodate high levels of motoring. Of particular importance is the provision of a high-grade urban ring road/bypass. Although most urban areas had plans for these, only a few achieved them: most notably, Birmingham, Glasgow, Manchester, Bath and Wolverhampton. In most other cases, these plans were only partly completed, while in others (e.g. Oxford, Bath and Inner London) attempts to build these types of roads ended in failure.

Figure 4.4: Selected towns – road provision, 2012

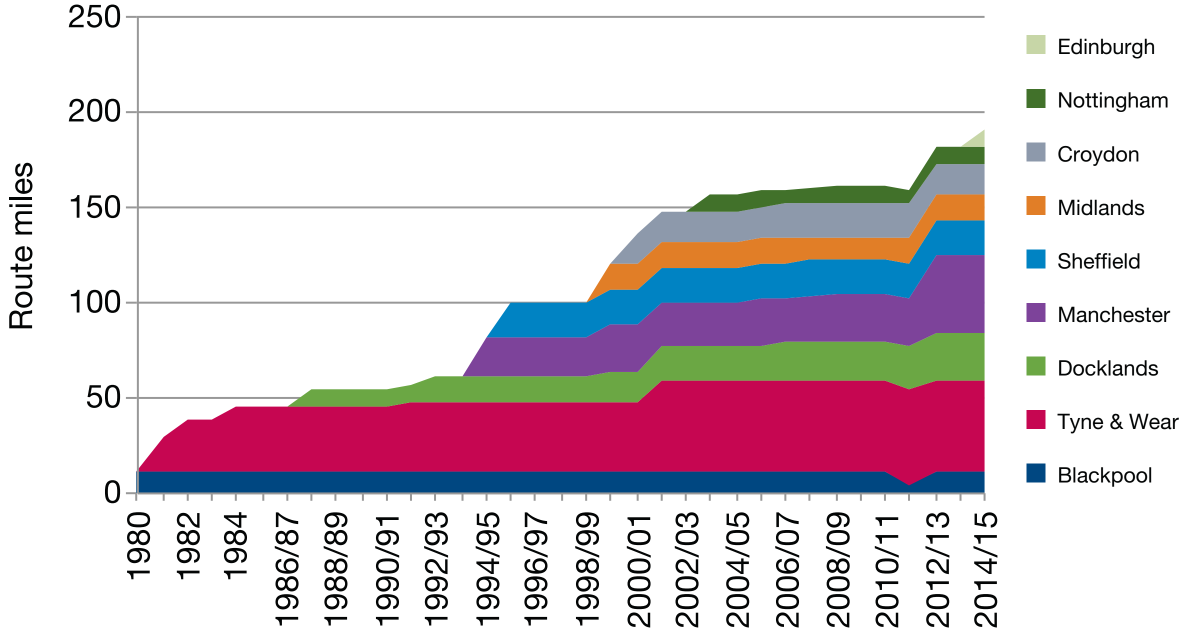


Source: DfT (2014s)

Meanwhile, comprehensive redevelopment planned to accommodate higher levels of motorisation more often met with success than failure. By the 1960s, most industrialised towns and cities had embarked on slum clearance programmes linked to urban renewal in inner cities and new towns or overspill estates. While designed to accommodate car ownership and use at the local level, these rarely provided the major infrastructure needed to match citywide motorisation. Ambitious attempts at redevelopment of town centres were few and far between (Coventry being a notable exception). In London, while separation of pedestrians and motor vehicles was realised in the Barbican redevelopment, an endeavour to do similarly with Covent Garden failed and marked an end to most aspirations of this kind.

As described above, the length of the national railway network has been much reduced over this period, but the core system and many terminal stations have been extensively modernised. Operating efficiency has increased dramatically, with the number of staff reduced from 475,000 in 1962 (British Railways Board, 1964) to only 66,000 today (DfT, 2014w). Journeys speeds have increased on most routes, with the replacement of steam haulage by diesel and electric traction in the 1960s. Meanwhile, some types of traffic have virtually disappeared (e.g. parcels), while others (e.g. airport access) have developed strongly and, as described below, increased parking at stations has improved car-borne access to the railways.

Figure 4.5: Growth of light rail/trams systems in Britain, 1980–2014/15



Source: DfT (2014x), DETR (1997b)

The 1980s saw the reintroduction of light rail and tramway systems. At the turn of the 20th century, more than 200 British towns had tramways (Wikipedia, 2014a), but by 1962 the only survivor was the much truncated Blackpool tramway. Many towns and cities have tried to build new light rail systems, and with the opening in 2014 of the Edinburgh tramway there are now just nine light rail/tram systems with a total length of 191 miles (DfT, 2014x, Transport for Edinburgh, 2014) carrying about 940 million passenger miles a year (DfT, 2014y). These have improved mobility and reduced congestion and pollution in the corridors they serve, but the general impacts have been small with their ridership making up less than 1½% of all public transport use and no more than 5% of urban public transport ridership.

Another infrastructure innovation has been various kinds of busways. The first of these – in Runcorn new town – was a figure of eight and was opened in 1971; subsequently, a further 14 have been opened (of which 12 survive) (Wikipedia, 2014b). However, not all of these have their own rights of way and only a handful have guideways. Overall, these busways have been successful, if occasionally controversial and costly. If well designed, they can offer a flexible and affordable way of providing good-quality public transport services where light rail systems are impracticable or too expensive.

One of the most important transport infrastructure changes over the last sixty years has been the provision of off-street parking facilities for homes, workplaces, in town and commercial centres and at transport hubs. By 2011, 39% of dwellings had garages and a further 27% had access to other off-street parking spaces; of the remainder, 20% parked conveniently on the street while the 15%[4] balance had inadequate or no provision for their vehicles (DCLG, 2013). With the arrival of high-quality weather protection for road vehicles along with pressures on accommodation, many domestic garages have been converted to living/storage areas. Between 1961 and 2011, the number of dwellings increased by two thirds – from 16.3 million (The Economist, 1997) to 26.9 million[5] – and a rough estimate gives an increase in the number of garages from 6 million to 11 million and other off-street parking spaces from about 4½ million to about 7 million.

Much additional off-street parking has been provided at workplaces for employees. Almost 18½ million employees travel to work by car (Gomm & Wengraf, 2013, The Scottish Government, 2013), and with three quarters of these using their employers' car parks there must now be well over 10 million workplace parking spaces, compared with fewer than 2 million in 1960. It is also estimated that there are between 3 and 4 million publicly available non-residential, off-street car parks currently in Britain (Bates & Leibling, 2012).

Parking at railway stations has also increased substantially over this period (both in off-street and on-street spaces). As car ownership grew and households progressively switched to central heating, land used as rail-served coal yards was converted to car parking. Nowadays, with the growth in rail-based park-and-ride, one in every five rail journeys starts by car.

7 Technology

There have been some remarkable developments in technology since the rapid growth in car ownership in the 1950s and 1960s, and these have affected accessibility, mobility and transport. Many have influenced the ways people and firms go about their business and have had direct and indirect implications for travel and transportation. Others have impacted on the transport systems themselves.

The arrival of widespread television 'ownership' in the 1960s cut dramatically into the use of buses for evening and weekend visits to cinemas. It also caused cinema attendances to shrink from 1.3 billion a year in 1950 to 0.2 billion in 1970. Then the availability of home fridges and freezers allowed larger loads of foodstuffs to be purchased, thus favouring the car for shopping. Affordable electric washing machines saw the end of most trips to the laundrette, and the widespread adoption of electric-, gas- and oil-fired central heating (along with clean air legislation) put an end to local coal deliveries (and also depleted an important source of railway traffic).

Expectations that electronic communications would supplant physical

4 Totals do not cast to 100% due to rounding.
5 DCLG (2014), Welsh Government (2014b) & The Scottish Government (2014).

movement have been only partly realised, but with widespread coverage by the Internet (at home, at the office or by a mobile device) normal working at or from home has now grown to at least 5%, with many more people doing so on a more occasional basis. Internet shopping is experiencing double-digit growth, while on-line retail sales amounted to around £77 billion in 2012 (DBIS, 2012). (Back in 1960, remote shopping was confined almost entirely to catalogue purchases and a few specialist telephone purchases.) The Internet also provides education services, health advice, e-business, entertainment and a range of government services. The growth of Internet shopping and entertainment is getting a major boost from the spread of smart phones and tablet computers, and at present there are no signs of this trend slackening.

Clearly, some physical movement is being avoided by this phenomenon, but the effects are even wider. Improved communications encourage and enable new business and social linkages, which in turn can generate new journeys as part of their fulfilment. Internet purchases have to be delivered. Thus, van traffic grew by 65% between 1993 and 2013, compared with an increase of 13% in other vehicular movements (DfT, 2014b).

ICT is having important implications for transport operations and use. Improved scheduling, real-time user information, electronic ticketing, advanced traction and signalling technologies all serve to make public transport more attractive. Smart motorways, more sensitive traffic controls, satellite navigation and the ‘connected car (and lorry and van)’ help ease congestion and improve the travel experience for motorists. Mobile communications on trains, cars, goods vehicles and buses can mean that being away from base does not entail being out of touch, because time spent on public transport journeys and as a car passenger can be put to good use by working on the move.

Technological developments have greatly improved cars and car travel as well as reduced their costs. In 1956, the average wage for a man was £12.18 a week (The Economist, 1997) and a Ford Consul cost £706 (Dudley, 1956). Today, the average male weekly wage is £612 (ONS, 2014b) and a basic (but much superior) Ford Focus costs £14,000 (Ford, 2014). So rather than work for 58 weeks to acquire his new car, today's average male worker has to wait only 23 weeks. There have also been technological innovations that have had very little impact. Personalised Rapid Transit – heralded in the early 1970s as the new way forward for urban mobility (e.g. Cabtrack in Sheffield) has produced only a 'campus'-style system (ULTRA) serving part of Heathrow Terminal 5 parking. The Segway (from 2001) self-balancing electric scooter, which one luminary claimed 'as big a deal as the PC', has again largely been confined to 'campus'- type applications and a few specialist ones. The electric bike has so far had limited penetration in the UK – perhaps because of costs and the importance attached to cycling as a form of exercise. And who can remember the Sinclair C5 (from 1985)?

8 Governance and funding

At the onset of widespread motorisation, the local government structure strongly reflected the reforms of the late 19th century, which were not designed to meet the needs of the emerging post-industrial age and the challenges that the ubiquitous motor car presented. The shortcomings were most obvious in London, so the Greater London Council (GLC) and the 32 London boroughs alongside the City of London were created in 1963 to replace the former London County Council, metropolitan boroughs, Middlesex and parts of the Home Counties. While the GLC had responsibility for overall transport policy and major roads, London Transport was not brought into the system until 1970, and British Rail's operations remained under central government oversight but with a duty to cooperate with the GLC.

Reform of local government generally outside London had to wait until the early 1970s – and the 1972 Local Government Act. This rationalised the historic county structure in England and created six new metropolitan counties covering the main conurbations. Below the new counties were districts and boroughs, and below the Mets were metropolitan boroughs. The counties were responsible for transport and strategic planning, and the districts for local roads. The Mets took over the four Passenger Transport Authorities/Executives (PTA/PTEs) formed earlier, under the 1968 Transport Act, with new PTA/PTEs being set up for South and West Yorkshire. In 1974, central government funding was provided by Transport Supplementary Grant (TSG) on the basis of transport policies and programmes rolled on annually by local transport authorities, thereby providing the most coherent arrangements for the governance of local transport seen to date. These lasted twelve years, after which the GLC and Mets were abolished and London Transport was effectively renationalised. In the Mets, this turned the clock back to the early 1970s; but not so in London as the former London County Council had gone forever. Thus the weakest strategic government was in Greater London, where it was needed most. Following the recommendations of the Local Government Commission for England in 1992, some of the 1974 new counties (e.g. Avon) were split up and a number of towns in the shire counties turned into unitary authorities – increasing fragmentation of responsibilities for transport.

The weaknesses of these changes prompted further initiatives to establish local governance domains that accommodated the need to achieve more coherent transport planning, funding and management where existing local authority boundaries made least sense. In London, the Greater London Authority (GLA) was created in 2000 and Regional Development Agencies (RDAs) established between 1998 and 2000 to promote and coordinate planning transport and economic development in their areas. Later, in 2008, the PTAs were changed to Integrated Transport Authorities, which were the sole transport planning authorities for their areas. Four of these have now transformed into Combined Authorities, which include all local economic investment and transport responsibilities in their areas.

Outside London and the Mets, the picture is more confused. With the demise of the nine RDAs in 2012, the arrangements for coordinating transport policies and priorities were significantly weakened, although new bodies – Local Enterprise Partnerships (LEPs) – were set up to help fill this gap. There are 39 of these in England – made up of local authority and local business representatives – but these do not necessarily make logical transport planning areas. Local Transport Bodies (of which there are 38 in England outside London) are voluntary partnerships of local authorities and LEPs set up to decide which investments should be prioritised, to review and approve individual business cases for those investments and to ensure effective delivery of their programmes.

Since devolution in Scotland and Wales in 1999, transport has been the responsibility of the new national administrations. Transport Scotland is the executive agency of the Scottish government and is responsible for main roads, rail, aviation and ferries. The 32 unitary authorities are responsible for local highways, traffic and planning and are all members of one of the seven regional transport partnerships. These include Strathclyde, which is responsible for public transport in the Greater Glasgow area, while for the rest of Scotland regional transport partnerships act as joint boards responsible for transport strategy in their areas and for overseeing the implementation of policies and projects.

In Wales, the situation is not dissimilar, with Transport Wales responsible for national transport planning, main roads, rail services and aviation. The 22 local authorities are responsible for other roads, traffic, bus funding and planning and are members of four regional transport consortia, which prepare and coordinate regional transport policies, plans and programmes.

Local transport funding depends heavily, as do the rest of local government activities, on financial support from central government. Currently, English local authorities generate 43% of their income from their own means, with the balance of 57% coming from central government. Even the ability to raise funds through local taxes is circumscribed to some extent by central controls. This is set to change in future, with increases in council taxes and retained business rates making up the lion's share of funding (80% in 2019/20).

The funding regime has varied over the decades, but at the time of writing comprises integrated transport and highways maintenance block grants (which are not required to be spent on transport – making up 52% of allocations between 2011/12 and 2014/15) as well as specific grants (for local major transport schemes, local sustainable transport fund, green bus grant, private finance initiative (PFI) deals and capital grants for major local rail scheme; these must be spent on transport and make up the remaining 48%). From 2015/16, a new Single Local Growth fund will channel much of the transport capital grant through the LEPs, and this will complicate local transport funding further.

This pattern of changing funding regimes brings uncertainties to local transport planning and development and has resulted in substantial variations in fortunes for different areas. The frequent use of competitive bidding by local authorities has meant that the smaller authorities, with their limited in-house resources, have often faired less well than the larger authorities and groups of authorities – with London quite clearly having done particularly well in recent years. Indeed, one commentator (Cox & Davies, 2014) claims that, at the end of 2011, transport spend per capita was £2,700 for London but only £5 per capita in the North East.

On top of this confused set of basic funds, there is a range of *ad hoc* government grants. In respect of highway maintenance, the Chair of the Public Accounts Committee recently observed (Public Finances, 2014): “Since 2010, additional funding has been announced ten separate times, clearly showing that the Department has no long-term funding plan to make sure the road network runs properly.”

Together with the forecast reductions in real local government funding, increasing demands from adult healthcare, changing grant regimes, increased pressure to bring in private sector funding (e.g. through Section 106 payments) and divisions of responsibility with activation of LEPs, it is going to be very difficult for local government to devise and execute effective transport policies and programmes for their areas.

9 Conclusions

The last half century has seen powerful forces driving increased car ownership and use – with consequent reductions in bus use, cycling and walking. But much car use has been for new travel. While a substantial effort was made to deal with intercity traffic growth, coping with urban traffic has proved much more challenging. The difficulties of adapting existing settlements to accommodate the car were clearly identified, but adequate policy responses were few and far between. In the meantime, auto mobility has exerted steady and subtle pressures on urban form, which will be difficult to reverse.

Forecasting techniques and cost–benefit analysis have improved markedly and, despite significant shortcomings, outperform their policy responses. Changes in the regulatory regime have had mixed results. Traffic, vehicle, driving and parking regulations have played a vital role in keeping traffic flowing, reducing road accidents and managing local demand and environmental impacts. Deregulation of goods transport has improved the efficiency of freight logistics, but deregulation of buses outside London has seen a continuation in the fall-off of bus use in contrast to its growth in the capital. On the railways, following years of struggle as a nationalised industry, privatisation has forced the government to take responsibility for planning and providing substantially higher level of taxpayer support; and this has been associated with a doubling in passenger journeys and a 50% increase in rail freight.

The use of pricing to help manage transport problems has been limited. Developments in the tax regime has been effective in reducing emissions, and local parking charges have helped manage demand, while public transport fare regimes have been used to stimulate off-peak travel and to improve mobility of some sections of the community. The most effective use of pricing – variable road user charges – has proven to be too difficult politically outside central London and so remains a potential tool for future use.

Improvements to the urban roads infrastructure have been limited and patchy for understandable reasons: high costs, environmental impacts and a planning system that is generally acknowledged to make infrastructure improvements very challenging. The result is that many towns have road systems that provide poor service to road users and too often unsatisfactory conditions for those living and working alongside them. This remains a problem for many towns, especially where there are substantial flows of through traffic.

Much has been made of new light rail systems. While they have improved public transport in a few corridors, their wider impact has been limited outside London, Newcastle and Manchester. With the growth in car numbers, the rise in car parking was probably the most important infrastructure of the motoring age – mostly funded by private companies and households.

Revolutionary new technologies have been unrealised at urban scale but have provided substantial evolutionary improvement of established transport systems. Forecasts of disruptive information and computing technologies were also off the mark, with ICT doing as much to improve and reinforce physical movement as to replace it.

A key element of the problem of tackling the urban mobility problem has been deficiencies in governance arrangements. Local authorities are overly dependent on central government for resources and powers, governance structures have changed too often and the arrangements of the 1970s, perhaps best suited to coping with the urban mobility challenge, were abandoned but, outside London, are being slowly restored in part. The arrival and disappearance of agencies between local and central government has lessened continuity; coupled with uncertain and varying funding sources, this has weakened the capacity of local authorities to get to grips with urban transport issues. Looking to the future, a rebalancing of the resources and powers of central and local government to match the primary responsibilities of local authorities to tackle urban transport issues is essential if real progress is to be made.

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5. Shaping demand in urban areas

– by David Bayliss

1 Introduction

This paper looks at the reasons for urban movement, how this is arranged between different types of transport, what each form of urban transport may have to offer in future and how each might be better managed.

The pattern of urban travel is shaped by a range of economic, social, land use, transport-provision, technological and other factors. Some of these can be changed in order to reduce the amount of travel and change how trips are made to mitigate its unwanted side effects. Urban travel differs from general transportation as it is necessarily more local and makes less use of those types of transport better suited to longer journeys.

The future of urban travel demand must be seen in the context of population growth – from 61.9 million in 2012 to 69.7 million in 2032 – and the number of over 60s growing much more rapidly, from 14 million to 20 million (ONS, 2014a). These future 'seniors' will be more car orientated than those of today, with more than 6 million additional drivers in this age range out of an increase of 7½ million additional drivers[1], of whom 5½ million will be in urban areas. Incomes are also expected to rise, and if they match the last twenty years growth (ONS, 2012), should be 50% higher (in real terms) in twenty years hence. This will favour the higher-quality travel modes – trains and cars.

2 The characteristics and use of the different modes of transport

Air transport has no role at the urban scale, and coach travel makes a negligible contribution. Railways, however, can play a role in some situations but are limited by the relatively low density of railway stations. In London, where passenger rail transport is very important, there is almost one station (taking the four types of rail systems in London) for every square mile (ORR, 2014a, DfT, 2014b). Thus, for many medium and longer journeys, travel by rail is feasible. In Greater Manchester, there is one station for every five square miles, so a much smaller proportion of journeys could be practicable by rail. In most towns outside the larger conurbations, there are few stations and the contribution of the railways to urban mobility is minimal. There are some exceptions to this rule (e.g. Middlesbrough, Northampton and Bournemouth/Poole), but these are few and far between. Even where there is a local station, easy travel will usually be confined to a single corridor, and so travel to most destinations will require one or more interchanges, thereby making rail uncompetitive with other forms of local transport.

Less than 1% of rail journeys are shorter than two miles and under 10% shorter than five miles. In the under-five-mile range, rail carries only ⅓% of travel, and in the under-ten-mile one, just ¾%. The situation is different for the

1 Extrapolation from DfT (2014a).

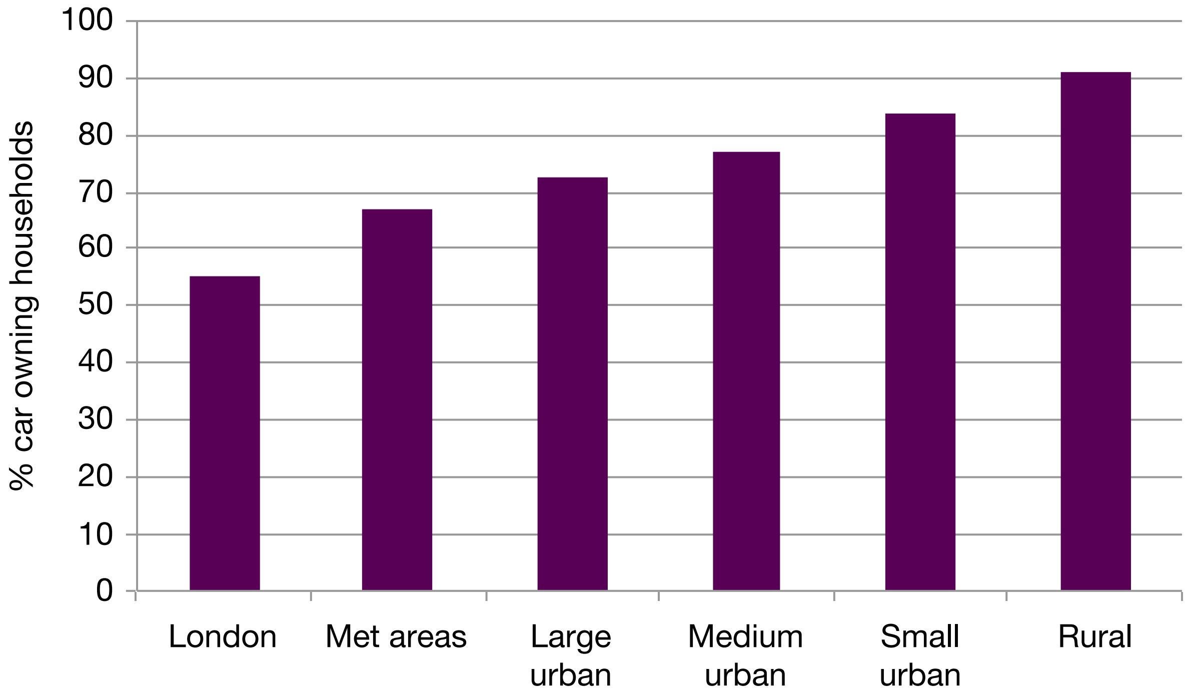
London Underground, where more than 60% of journeys are in the two- to five-mile range, and 95% within the two- to ten-mile range (DfT, 2014h).

While light rail can provide a service better suited to urban travel needs than conventional rail, its present reach is very limited. The nine systems (including Edinburgh Tram) total 197 miles in length and have 367 stops (DfT, 2014b, 2014e). As such, while they provide an invaluable service in a few corridors, their impact is small compared with buses. These systems carry about 230 million passenger journeys a year compared with more than 5 billion on local buses (DfT, 2014g); and of these 230 million more than a half are in London (DfT, 2014c, 2014d).

Buses are much more accessible than rail in that there are about 400,000 (NPTDR, 2014) bus stops nationally compared with only 3,000 rail (of all kinds) stations and stops (Ibid.), meaning that buses are better suited for short- and medium-distance journeys. However, the need to walk to and from a stop and to wait for a bus to arrive means that few very short journeys are suitable for bus transport. Only about 1% of journeys under a mile in length are made by bus, whereas about 12% of journeys between two and five miles in length (half of all bus journeys) are by bus (DfT, 2014h). Again for many potential journeys, the need to interchange makes the use of buses less attractive, and for longer journeys in towns the frequency of stops means that bus speeds are rather slow. Average bus journey speeds (including walking to and from the bus stop) average about 9 mph outside London and only 7 mph in London – slower than all other forms of transport except walking (DfT, 2014h, 2014i).

Travel by car has long been the dominant form of urban transportation for those with access to cars. Although car ownership is highest in rural areas, three quarters of households in towns own one or more cars, and even in the large conurbations this proportion is still two thirds. London is exceptional in that three out of seven households do not own a car. Figure 5.1 shows how car ownership increases as the size of urban area reduces. As households with cars are on average larger than those without, this means that outside London about 80% of people are in households with one or more cars.

Figure 5.1: Car ownership by area type – Great Britain, 2011/12



Source: DfT (2014j)

Generally, with few exceptions cars can range freely across urban road networks, except in the case of central London where there is a £10 daily charge on weekday (£11.50 if Autopay is not used) (TfL, 2014a). As such, cars do not require interchanges and usually can start their journey at their point of origin and finish close to their destination. Thus, for the majority of journey, cars are the fastest means of transport especially as they do not have to stop to load or unload *en route*. Compared with the average bus journey speed of 9 mph or so, the average speed of car journeys is more than 20 mph in most urban areas (DfT, 2014h, 2014i). This means that, for the same journey time, using a car gives access to about five times the area that can be reached by bus. Moreover, cars are able to carry several people and substantial amounts of baggage for much the same cost as with a single driver, provide protection from the weather and require little physical effort to use.

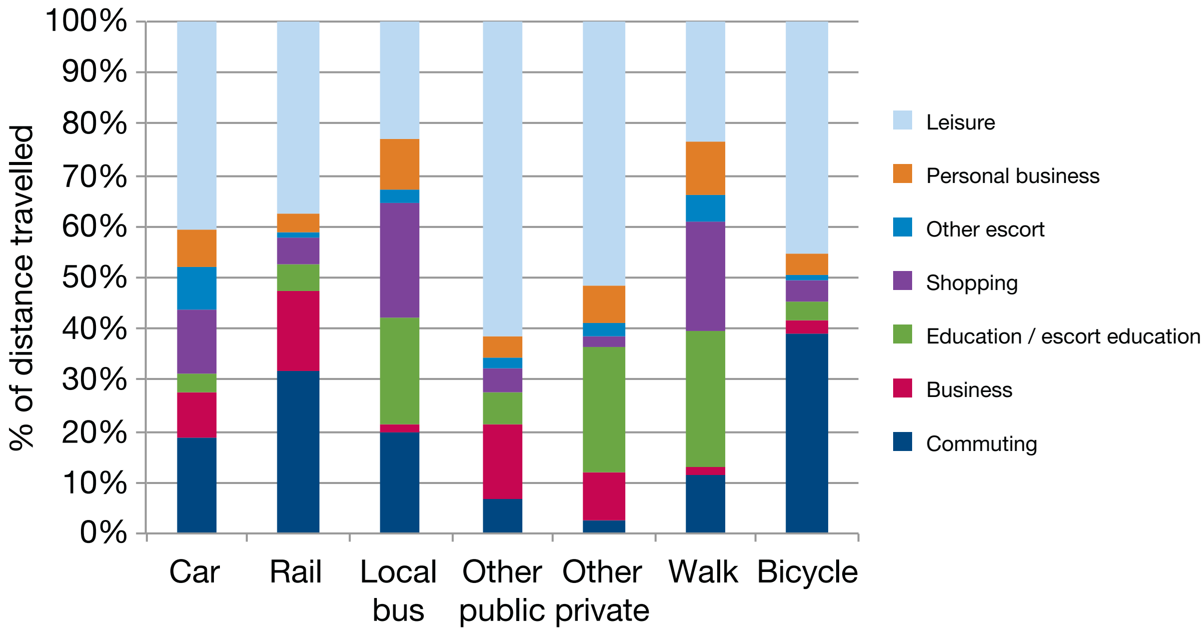
However, the costs of motoring are high: the average car-owning family spends around £3,000 a year on car ownership and use (compared with around £500 on public transport) (ONS, 2014b). With average standing costs at about 35p a mile and running costs about 20p a mile (AA, 2014a, 2014b), marginal travel costs are not that high. By contrast, public transport fares are strongly related to the distance travelled – even if period passes are purchased in advance. Rail fares average around 20p a mile (DfT, 2013c, 2013d) and local bus fares 17p a mile (DfT, 2013a, 2013b), so the financial advantage of using public transport is limited for solo travellers. With average car occupancies being

1.57 (DfT, 2014l), this puts average car use at a financial advantage – once the standing costs have been written out of the equation. Coupled with the time and convenience advantages, this makes the car the mode of choice for the majority of urban journeys, and this is reflected in how people travel in Britain's towns and cities.

Cycling has attracted a good deal of attention in the last five years or so, and it figures strongly in national and local governments' transport policies. Despite this, cycling levels overall have not changed much recently, and cycling has a limited role in providing urban mobility. Only 10% of people cycle at least once a week, and 15% of people at least once a month (DfT, 2013e). Just over 3% of urban workers commute by bike (DfT, 2013f). At least half of cycling is for recreation, and as such contributes little to meeting the need to get from A to B. Commuting by bike is most prevalent for journeys under three miles, and two thirds of all cycle commutes are under six miles. London stands out as an area where cycling to work has grown significantly – doubling between 2001 and 2011 to 3.9% of workers overall – and more in Inner London. But this proportion is quite small when compared with high cycling towns of Oxford and Cambridge, with 29% and 17% of commutes by bike respectively (DfT, 2013g). Cycling is a reasonably speedy form of transport for short distances, as unlike public transport, there is usually no need to walk to and from an access point. Average journey speeds in urban areas are in the range 7–8 mph (DfT, 2014h, 2014i), and so cycling is competitive with buses. Marginal costs are low; however, bad weather, the physical effort required, lack of safe parking and concerns about road safety can be off-putting – 61% of people think that cycling on roads is too dangerous (DfT, 2014k). This physical effort does however have health benefits, which make cycling attractive to some.

These average figures do not fully reflect the particular characteristics of the service offered by the different form of transport. While rail plays a very limited role outside London and the large provincial conurbations (just 7% of Britain's population uses rail at least once a week (DfT, 2013h)), it is particularly well suited to carrying people between the suburbs and beyond to town and city centres. Buses provide well for shorter journeys generally and for medium distances into town and city centres. With two thirds of walk trips under a mile in length (DfT, 2014h), walking is extensively used in its own right for short journeys and as the main means of access to bus, tram, metro and rail. Cycling, other than its value as a recreational pursuit, is suitable for short- and medium-distance journeys to work anywhere in the urban area. Car (and to a lesser extent motorcycle) travel can satisfy most travel needs well; however, parking difficulties and road congestion reduce its utility when travelling into congested town and city centres.

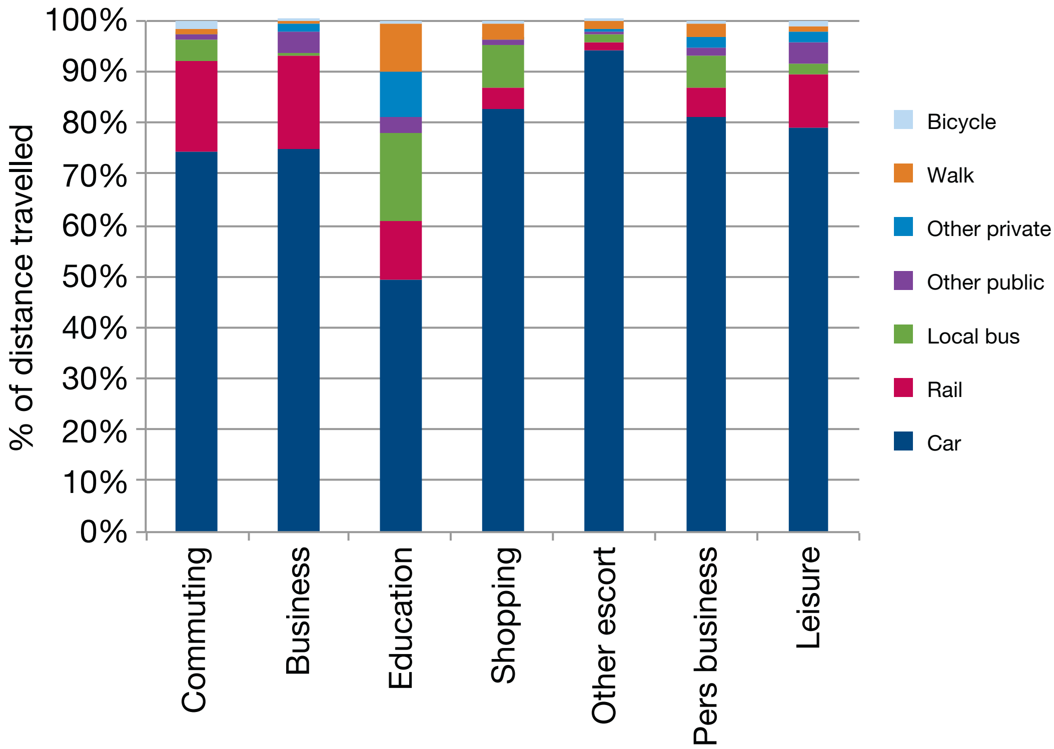
Figure 5.2: Travel purposes by mode in Great Britain, 2011/12



Source: DfT (2014m)

Figure 5.2 is for Britain as a whole so is not completely typical of urban areas. This shows that rail is chosen mainly for commuting, business and leisure. Bikes are used overwhelmingly for commuting and leisure, while walking is popular for school journeys, shopping and leisure. Apart from business travel, buses are used for a broad mix of purposes, as are cars, except that the latter are chosen more for leisure and less for education travel than buses. Figure 5.3 shows the weight of each form of transport by travel purpose. Here it can be seen that because car use is so dominant, it is responsible for about half the total travel even for purposes where it is least popular.

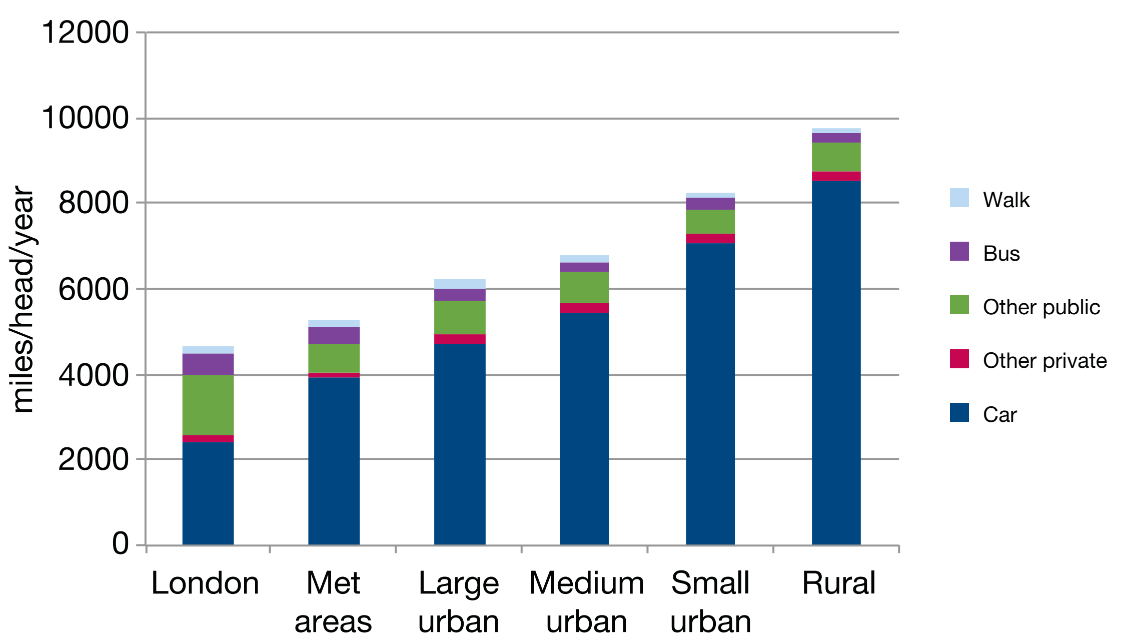
Figure 5.3: Personal travel purposes' modal shares in Great Britain, 2011/12



Source: DfT (2014h)

Figure 5.4 reveals the use of the different forms of travel by type of urban area. London stands out in that Londoners travel substantially less than people in the rest of Britain. This is partly because they make fewer journeys (14%) but also because they travel shorter distances (17%). This might seem surprising with the high level of rail use in London – but much of this by the three quarters of a million commuters coming each weekday from outside the Capital. Whilst its rail system carries a third of all Londoner's travel the Capital also has extensive bus use with almost half of all motorised transportation going by public modes. The extensive use of public transport with its access times and the slow pace of traffic in London mean that average journeys speeds there are lower than elsewhere: although more highly differentiated with fast radial rail journeys and slow bus and car travel in inner London.

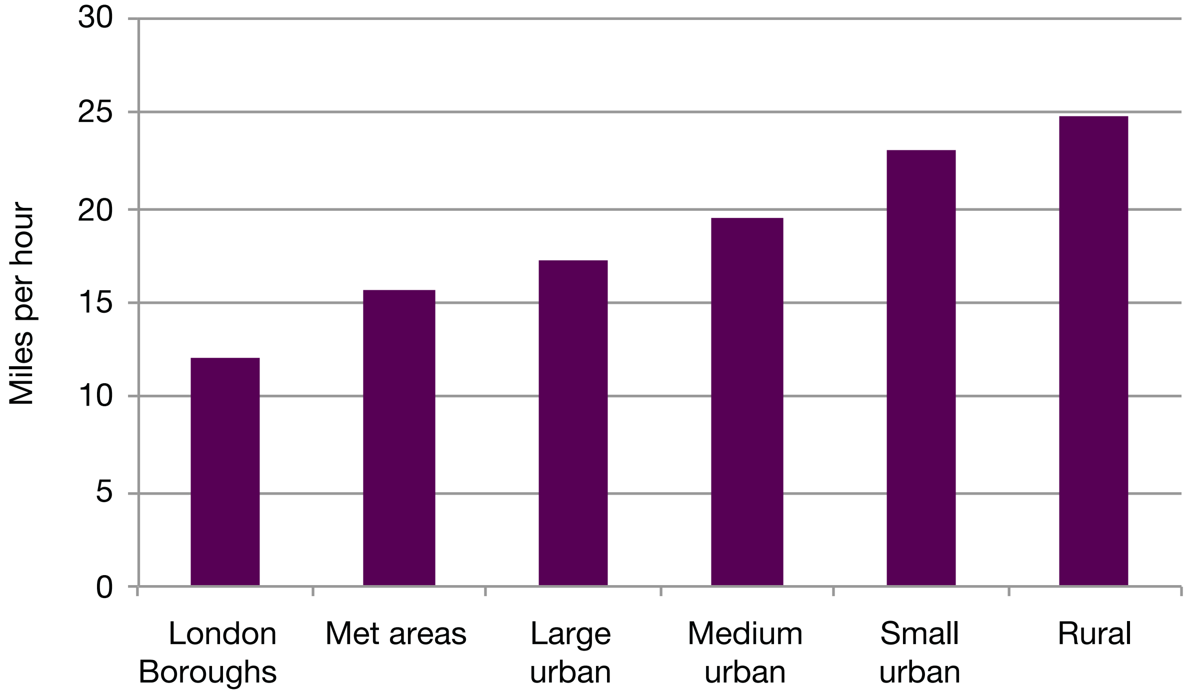
Figure 5.4: Personal travel by area type in Great Britain, 2011/12



Source: (DfT, 2014n)

Car use in the Metropolitan Areas outside London (Mets) although significantly lower than average, is 60% higher than in London – and public transport use is 45% lower. The greater use of cars and higher journey speeds are associated with 13% more travel, although still a fifth lower than the national average. This pattern continues through to the small towns, where public transport use has shrunk to 10% of all travel while the extent of travel is 8¼ thousand miles/head year – 22% more than average. Figure 5.5 shows a clear correlation between the car share of travel and average journeys speeds.

Figure 5.5: Average person journey speeds (all modes) in Great Britain, 2011/12



Source: DfT (2014n, 2014o)

Goods have to move to, from and around urban areas and freight makes up a significant amount of urban traffic movement. While non-road transport contributes to goods movement into and out of urban areas, it carries hardly any freight traffic within towns and cities. (These goods movements exclude piped fluids – gas, water, sewage and drainage). The lower non-road freight in urban areas reflects the types of products that are shipped, smaller size of consignments, the limited number of terminals and the costs and delays from multiple handling.

As a result of these features and the growing pressures to reduce itineraries and waiting times for 'fulfilment', road transport is firmly established as the main means of shipping goods in urban Britain. Almost 16% of urban traffic is made up of commercial vehicles – more than 13% by vans (DfT, 2014p). Van traffic has grown by two thirds in the last twenty years, compared with only 13% for other types of traffic (DfT, 2014q). Overall, urban traffic comprises 53% of total traffic and has been growing less than non-urban traffic. Heavy goods vehicles (HGVs) form only 2½% of urban traffic, compared with 5% nationally, and as one would expect most (85%) bus traffic is in urban areas.

Given the importance of road transport to urban mobility, traffic congestion is a major factor in conditioning the ease/difficulty of getting around towns and cities: 45% of people think that traffic congestion in towns and cities is a serious or very serious problem, and the Eddington Report (2006) estimates that 89% of current congestion is on urban roads. Despite this, car travel remains the dominant form of transport in urban Britain. The reasons for this – speed, convenience, comfort, ubiquity and relatively low marginal costs – will not be changed easily and to do so would require draconian and probably very unpopular policies. Other forms of transport have their 'domains' where they perform well, but these overlap to only a limited extent the range of situations where cars have a natural advantage.

3 Electronic communications

Mobility is a key, but not exclusive, component of accessibility, while electronic communication is also important. Although the electric telegraph was introduced in the first half of the 19th century (ironically by the Great Western Railway), it was the invention of the telephone in the second half of that century that heralded the widespread use of electronic communications. In Britain, telephone ownership has long paralleled road vehicle ownership: in 1938, there were 3.01 million road vehicles and 3.01 million telephones; and in 2013 there are 33.4 million land lines and 35.5 million road vehicles[2]. As well as traditional telephones, radio and TV there are now mobile phones, a rich mix of different types of personal computers and the Internet. The distinctions between discrete types of electronic communication media being more blurred, as well as the growing functionality of these, mean that electronic communication is replacing the need to travel in a range of situations. However, improved electronic connectivity also extends social and economic networks, which in turn generate some new travel.

Given the rapid pace of change in this type of technology and how it is used, it is not clear how this balance between substitution for, and promotion of, physical movement is currently playing out. However, at the urban scale there are two fairly clear trends: increased working from home; and teleshopping. Internet access has grown from 9% in 1998 to 84% today (ONS, 2014d), while the number of employed people working from home also increased.

Working from home is less common in urban areas than in the countryside. Using the 2011 census definition, 5.4% of the employed work from home; in the Mets 3½% of the economically active work from home, while in more rural areas the rate is 7¼%. Some areas (e.g. West Devon and West Somerset) saw rates above 12% (ONS, 2013, National Records of Scotland, 2014). The propensity to work from home seems to be less conditioned by the availability of good-quality telecommunications (typically rural areas have lower broadband speeds than in towns and cities) but by type of work (e.g. self-employed, agricultural, non-manual) and lack of good local transport. Self-employment increased from 11.8% of the workforce in spring 2001 to 15%% in spring 2014 (ONS, 2014c) – a similar rate to the growth in home working.

2 Bob's Telephone File (2013) & DfT (2014r).

Teleshopping goes back at least to the 19th century with mail-order catalogues – again, ironically, facilitated by the development of the railway system. But the smartphone and the Internet have given this a substantial boost over the last twenty years, and online shopping is now estimated to be about a fifth of the total retail market (Rigby, 2014). This has been associated with an increase in delivery vehicle traffic, despite some purchases not requiring physical transportation (e.g. music, videos, software and tickets). Van traffic has grown by 65% over the last twenty years – almost 17 billion miles a year – of which about 6 billion has been in urban areas (DfT, 2014q, 2014s). Internet online shopping will have been only a contributor to this, however. During this period, shopping trip rates have reduced overall by about 14%, but car use has not – with a car driver (per capita) increase of around 18% compared with less than 5% for all car driver travel (DfT, 2014t, 2014u). Allowing for the rise in Britain's population from 56.1 million to 62.3 million (ONS, 2014e) over this period, this would have added 6½ billion car miles. While it is not possible to draw solid conclusions from these trends, they suggest that, although retailing accessibility has improved, the road traffic suppression from online shopping has not been significant and there may have been a net increase in traffic as a result.

What this means for the future of urban mobility is uncertain. Electronic communications seem set to develop faster than physical transport systems and will continue to help improve transport operations and effectiveness. The opportunities to substitute electronic for physical accessibility will expand, but the take-up will depend on lifestyle choices as well as public policies for urban transport.

4 Land use changes

If improved telecommunications are likely to have only a limited impact on urban mobility, what other measures are available? Changing the layout of towns and cities could improve accessibility by reducing the need to travel. Land usage patterns have an important influence on travel activity (see Figure 5.4), but in Britain land uses generally change slowly and the ability of the planning system to influence these adjustments, in order to reduce travel demand, is limited. Recent developments in planning policies are helping to contain sprawl and out-of-town developments, but the results of research into the effects of land use policies to promote higher densities and mixed uses (Pauley & Pedler, 2000) indicate that these, on their own, have limited effects on travel demand. However, if coupled with policies to restrict car use, and aided by improved public transport, they can help moderate travel demand and car use. In short, well-designed settlements are a necessary but not sufficient condition for lean travel. The key uncertainty here is where the 300 thousand new homes needed each year (CBI, 2014) and the associated jobs will be located.

5 The future potential of the different modes of transport

As with most other forms of transport, the raw capacity of heavy rail exceeds ridership. At the main city termini, fewer than half the available seats are occupied, and even in the busy morning peaks outside London there are half as many seats again as passengers. The situation in London is different, with only 4% spare capacity overall – meaning that at most termini and on many trains there are standing passengers. In the busiest single hour, up to 25% of standard class passengers can be standing on the busiest sections of routes in London, 18% in Leeds, 14% in Manchester and 11% in Sheffield (DfT, 2013i, 2013j).

The government is forecasting increased use of the railways between 2011 and 2030 of around 38% in London and the South East, 21% on the regional railways and 56% on long-distances service (DfT, 2012). It has plans, already underway, to increase capacity accordingly, from extra carriages and longer trains at one extreme through to a new £50 billion High Speed Rail line between London and the North at the other (DfT, 2013k). More than £9 billion is being invested in the existing railway system between 2014/15 and 2018/19 (HM Treasury, 2013). If the government's forecasts of growth in rail use are realised, then total rail journeys will increase by half a billion each year and travel distance by 14 billion passenger miles. Rail trip rates will have increased from 22 per head per year to 27, and average annual distance travelled from 550 miles to 680. The effects of this will be mainly outside most towns and cities, but there will also be improved rail travel between the suburbs and beyond into the larger city centres.

Over the last thirty years, 177 miles of light rail route have been constructed and an annual ridership total of 230 million journeys achieved[3]. This growth in traffic has been driven largely by increases in route length as the traffic densities have remained within a range of 4–5 million passenger miles per route mile. In future, it is possible that traffic densities on existing light rail lines will increase, but any new lines are likely to be less effective (on the assumption that the best routes were developed first). Thus, overall, it is not expected that traffic densities will rise much. If light rail is expanded at the average rate of the last twenty years, total system length would increase to 300 miles and ridership to 1½ billion passenger miles or 360 million passenger journeys a year.

Bus travel has reduced by a fifth over the last twenty years (DfT, 2014x) so potentially greater use could be made of this form of transport. Here, the issue is not one of capacity: with average bus occupancies of under 10 outside London (over 20 within London) (DfT, 2014y) there is spare capacity, which is not effective. Figure 4.1 shows how the fortunes of local bus travel have varied between different parts of Britain. This suggests that, given the right conditions there is scope for a substantial increase in the role of buses in urban mobility. If half of London's bus traffic growth from the mid-1980s had been experienced

3 DfT (2014v), DfT (2014w) & DETR (1997).

in the Mets and a quarter in the rest of the country, there would now be a billion more local bus journeys a year outside the capital, and local bus per capita trip rates would be 65 journeys a year compared with the current 48. The rate would be significantly higher in the Mets, but still lower than the London figure of 140. Although not all these journeys would be new an increase in bus trips would provide a substantial increase in urban mobility outside London. Overall, allowing for population increases, this would mean 7 billion journeys and 28 billion passenger miles by local bus in the early 2030s.

Car travel's domination of urban mobility seems set to continue. While the growth in overall car traffic has slowed of late, women's share of car/car traffic increased from 38% in the mid-1990s to 45% today. Car travel (per capita) is forecast to increase from its present level of 3,900 miles per year to 4,600 by 2040, and car traffic on non-trunk roads by 37% (DfT, 2013l). Urban traffic can be expected to grow at a slower rate than this, because of congestion – even a 25% increase would provide a substantial rise in urban mobility.

Cars are used for around 200 billion person miles a year of urban travel and 25 billion journeys. A 25% increase would add 50 billion person miles and 6 billion or so new journeys. Car occupancy rates have been slowly falling, as multi-car ownership has increased and household sizes reduced, from 1.59 in 2002 to 1.57 in 2013 (DfT, 2014l). This means that two thirds of potential car travel capacity goes unused, with commuting and business travel having the lowest average occupancy rates (1.2 persons per car (DfT, 2014α)). Average household sizes in England are forecast to reduce further – from 2.36 to 2.33 between 2011 and 2021 (DCLG, 2013) – putting additional downward pressure on car occupancy rates. New ways of accessing cars are being introduced such as car clubs and peer-to-peer car sharing and new smart-phone-based applications can facilitate these. These new access regimes offer the potential to overcome the problems of early car rental schemes such as those in Amsterdam and Montpellier. Indeed, a number of 'Autolib' schemes are already operating, including in Paris – which currently uses 2,500 small electric cars (Henley, 2014).

It is too early to say how these schemes will extend beyond niche urban applications and low-density rural applications where public transport is sparse. However, to the extent they develop, they seem likely on balance to increase overall mobility despite substituting for some conventional ownership car ownership and use (Le Vine, 2012).

Urban car use is affected by public policies, which are typically aimed at improving road safety, reducing congestion and limiting vehicle emissions and other environmental nuisances. Where policies effectively reduce congestion (e.g. town centre parking restrictions), they contribute to mobility by improving the speed and reliability of movement, offset in part by fewer car journeys. Where they are designed mainly for safety or environmental purposes (e.g. 20 mph zones), such policies will tend adversely to affect car-borne mobility.

Parking controls are the main public policy tool to influence car travel demand. However there is little evidence that residential parking restrictions have much influence on car ownership (Palmer & Jones, 2010), but town centre parking restrictions, especially if coupled with park-and-ride provision, can limit car use to congested centres. However, the existing provision of large amounts of parking in urban areas – much of it free of charge – means that, in the absence of measures to control the amount and price of private non-residential parking, parking controls will remain limited in their ability to manage traffic demand and congestion.

While the problems of implementing more ambitious plans to regulate excessive traffic seem stubbornly persistent, some exceptions to this have emerged. London's congestion charging has had a significant impact, yet only covers 1.3% of Greater London. Traffic in the congestion charging area reduced by 16% between the late 1990s and 2010, while, between 2007 and 2012 central London traffic speeds fell slightly (TfL, 2010, 2011). Powers to introduce Workplace Parking Levies have so far been used only by Nottingham, where the effects are not yet fully evident; and attempts to introduce congestion charging in Manchester and Edinburgh have failed. While some form of area-wide road pricing offers the promise of being a powerful tool for moderating congestion, there is no evidence yet of a popular desire to pick it up and put it into effect.

Low emission zones also restrict the use of some types of motor vehicles in a defined area and are now in operation in 5 areas but only one extensive location – London (European Commission, 2014). With growing concern about vehicular NO_2 and particulate emissions, it seems probable that these will become more common. Such restrictions apply only to vehicles that do not conform to prescribed emission standards (at present, mainly commercial vehicles) so they will not necessarily impact urban mobility. However, affected motorists may have to switch to more modern/low emission vehicles, and this could increase their travel costs but overall impacts on car use are likely to be small.

Perhaps the most important potential development in urban mobility is the improvement of the road networks in towns and cities. With peak speeds ranging from as low as 9 mph to as high as 40 mph (DfT, 2014β), and traffic densities varying by a factor of ten (DfT, 2014ɣ, 2014δ), clearly some urban road networks are providing a much higher level of service than others – and this affects not just car traffic but also commercial vehicles and buses. Where traffic speeds are low, there is usually little spare capacity. Increasing capacity will, all other things being equal, reduce delays and allow higher traffic flows. Where carefully designed, additional capacity can reduce traffic pressures on sensitive area such as town centres and, with smaller towns, remove through traffic generally.

Traffic congestion occurs principally on main roads. In urban Britain, only 11% of roads are A-roads and motorways (DfT, 2014ε). Of the total 5% of the land area that is made up of roads, just 1% is main roads (DCLG, 2007) and these carry about 60% of traffic (DfT, 2014p). Limited remodelling of the most congested sections of urban road networks could potentially increase capacity by between 10% and 20%. This would accommodate 20 billion to 40 billion person miles of travel or 2⅔ billion to 5⅓ billion journeys per year. This is less than the 50 billion suggested as needed above, but the balance should be capable of being dealt with by improved traffic management and more aggressive traffic restraint.

Recent improvements in the provision of facilities for cycling have extended the potential capacity of this means of transport to enhance urban mobility. So far the impacts appear to have been mainly in a few, rather distinctive areas as described above. Although many people currently think that cycling on roads is too dangerous, with continuing efforts to reduce cycling accidents there is clearly substantial potential for increased cycling, though this would not all be for utilitarian purposes – less threatening road conditions, more secure parking and cultural changes all appearing to be significant factors. If the average level of urban cycling commuting could be increased from around 3% to 6% by the early 2030s – a not unreasonable aim – this would increase the number of journeys from 1¼ million to 2½ million, with a small effect on car commuting.

After cars, walking is the most popular way of making journeys in urban areas – with 22% of journeys being made on foot (DfT, 2014t). However, walking has become less frequent, with a 5% reduction in walk journey rates in cities and large towns and a 15% reduction in medium sized and small towns between 2002/03 and 2011/12 (DfT, 2014ζ). This decline is partly due to the availability of free bus passes for pensioners and, for women, because of increasing access to cars. Should walking's share of travel continue to decline at this rate, the impact on distance travelled would be small, but urban mobility would nevertheless be adversely affected. The fact that 40% of people agree that they could just as easily walk rather than go by car for many short journeys (less than two miles) suggests that halting, and possibly reversing, this trend may be feasible.

Over the years, the prospects of new forms of transport emerge from time to time but rarely seem to overcome the laws of economics and physics and the peculiarities of human behaviour. To have a major impact, any new technology will, almost certainly, have to harness the ubiquity of the urban roads and so engage in what is one of the most challenging operating environments. A current example of an innovative transport development is the proposal by the Transport Systems Catapult (TRC, 2014) to test driverless pods in Milton Keynes, although it is unclear what transport problem this addresses. It is possible that some new revolutionary urban transport technology will be developed, but the environmental, social, economic and engineering challenges of devising a safe, effective and acceptable system are such that this is not likely to be in the near future. More likely, we will see refinements and developments of existing systems, as has been the case in the past. Better information and routing, driving advice and support, improved information and scheduling, and more efficient and cleaner traction systems all seem probable and will enhance urban mobility efficiency and safety.

6 Transport pricing

Pricing has long been used to regulate transport behaviour; to reduce environmental damage; to assist the mobility of particular social groups; to moderate traffic congestion; and to promote off-peak public transport use. There is no reason to suppose this will not continue; however, pricing regimes may change. While pay-as-you-go road pricing could have substantial congestion reduction benefits, as indicated above, prospects for its introduction seem limited. In the Foundation's 2007 *Roads and Reality (*Banks et al., 2007*)* it was concluded that, while road pricing would also encourage mode shift to public transport and walking and cycling for local trips in urban areas; in conurbations and other congested urban areas there would need to be a complementary package of additional road capacity, public transport and other measures.

General motoring is already more highly taxed than most other products and services, and there seems little appetite for significantly higher average tax levels (as opposed to greater differentials in component tax rates) (Bayliss, 2014). Indeed, over the last decade direct motoring taxes (per vehicle mile) increased by 23% compared with a growth in the retail price index (RPI) of 37%(ONS, 2014f).

Public transport fare tariffs are already highly differentiated, especially on the railways, where peak and off-peak elasticities are higher (Balcombe et al., 2004), so the prospects for substantial changes in travel behaviour from commercial restructuring of tariffs are small. Substantially lower average fares would increase the use of public transport and effect some reductions in car use. However, overall fare elasticities are low, and, with government expenditure on public transport running at around £10 billion per year (Bayliss,

2014) and a general agreement that public spending has to be strictly controlled, the possibilities for a major increase in government support for public transport subsidies, beyond that already committed, are low.

7 Freight

Freight in urban areas will continue to go by road, as most of the prospective innovations for 'smarter' freight transport are based on the flexibility and ubiquity of road transport. Should longer-distance freight to and from urban areas switch to rail, then there may be potential for rail trans-shipment depots at a few peripheral locations of large cities. Where these have been successful, they have usually been accompanied by bans on large lorries in the inner city and been part of a wider logistic centre with break bulk/consolidation of road freight and warehousing. As such, they need to be large to be economic and therefore require substantial tracts of land. Should any of these be developed in Britain, they will probably be few and far between and of little relevance to most towns and cities. Government forecasts show van traffic growing twice as fast as cars (DfT, 2013l), and on this basis van traffic will make up a quarter of all vehicular traffic on urban roads by the early 2030s.

8 Conclusions

Probably, the most important change affecting the demand for urban mobility will be the 8 million population growth and the increase in car drivers from 36 million to 43 million. Higher incomes will mean that people have more to spend on travel and purposes of travel, and this will tend to favour the higher-quality travel modes – trains and cars. Urban travel patterns are also shaped by the capacities and capabilities of the different form of their transport assets. Prices and public regulations also have influences but can only go so far in moderating the underlying social, economic and technological factors driving people's travel behaviour.

Each means of transport has its strengths and limitations. Rail networks are too sparse to play a major role at the urban scale outside the London region and, to a lesser extent, the metropolitan conurbations. Rail services are often crowded at the times and places they serve best, and plans to expand the capacity of the network should increase rail usage by about a third in the medium-distance markets with up to an additional five or so journeys per capita per year.

Buses provide acceptable transport in the two- to ten-mile range but have carried a diminishing proportion of travel in urban areas outside London. Better integration and traffic priorities (including dedicated busways in busy corridors) have the potential to increase bus use outside London by a third – carrying a billion or so extra journeys a year.

The London Underground is carrying its highest-ever levels of traffic, with more than 1¼ billion journeys a year, and so suffers from heavy crowding. Scope for increasing its current capacity is limited and major extensions will be costly, although, when opened in 2018, the £14.8bn Crossrail will carry 200 million journeys a year and increase London's rail capacity by 10% (Crossrail, 2014). Further developments – Crossrail 2 (TfL, 2014b) – are being considered, and these could further enhance the role of rail in meeting London's transport needs.

Light rail carries fewer than four journeys per capita per year, and half of these are in London. Growth in its use is heavily dependent on new and extended lines, and this could grow to six journeys per capita per year with its contribution to urban mobility confined to a few radial corridors in larger cities.

Walking and, to a lesser extent, cycling will remain the most popular means of making short journeys and accessing motorised transport systems. Safer and more agreeable conditions for these forms of travel will encourage them, but they are unlikely to make a significant dent in the overall demand for motorised transport.

The car seems set to continue to dominate urban mobility for the foreseeable future. While policies to reduce noise and emissions from motor vehicles have been effective and will make further improvements, attempts to restrain car use to moderate urban traffic congestion have met with only limited success. This may change as the economic case for and practicability of efficient pricing has been clearly demonstrated; however, the public and political antipathy for the introduction of road pricing shows little sign of waning. Yet many towns and cities have road networks poorly adapted to the needs of motorised society, with consequential congestion and environmental nuisance. Remedies for these shortcomings are expensive and controversial, but in the absence of targeted improvements to many urban road networks congestion will worsen and town centres continue to suffer.

Urban freight also seems set to continue to be almost entirely road based, and again improvements to road networks and their management will be needed if traditional town centres are to thrive. With the worst congestion typically occurring on only a fraction of the 11% or so of roads that comprise main road networks, some improvements should be practical and affordable if the additional ten million hours of (all) urban traffic delays expected by 2040 are to be avoided.

Developments in automotive, communication and other technologies have long had some influence on travel in towns and will continue so to do. However, despite these, there has not yet been a transformational change since the onset of widespread car ownership and the demise of traditional trams and trolleybuses. While there are exciting developments in prospect – especially the closer integration of ICT, road vehicles and road infrastructure – the possibility of a disruptive change, at least to the author, looks small. In the absence of such a change, the forces that have shaped urban travel demand in the past will continue to dominate, with perhaps the greatest uncertainty being where the seven million or so extra people expected in Britain's towns and cities over the next twenty years will live.

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6. Maximising the use of the road network in London

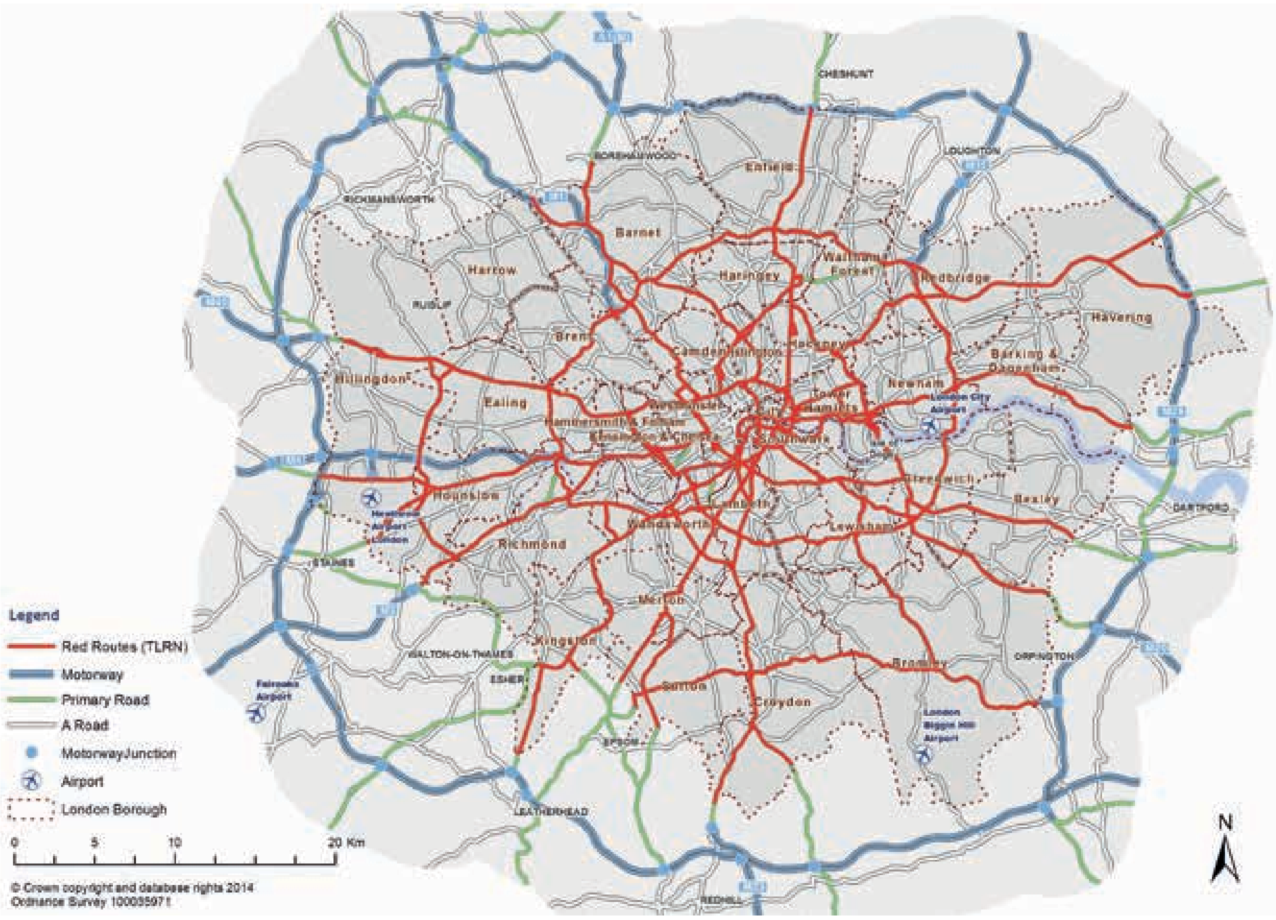
– by Garrett Emmerson, TfL

1 Introduction

Transport for London (TfL) is the Capital's strategic transport authority. It is one of only a handful of urban transport authorities in the world that brings together the operation of all major modes of public transport and the management of the road network under the auspices of a single integrated organisation. In spite of the extensive network of rail-based public transport that it operates, more than 80% of the 29 million trips made by Londoners every day take place on the road network, along with around 90% (by volume) of freight movement. Keeping the road network moving and operating as efficiently as possible is therefore one of TfL's key day-to-day challenges.

TfL's road management responsibilities can be broadly divided into three parts. Firstly it owns, and is solely responsible for, the operation of the Transport for London Road Network (TLRN) or 'Red Routes', which consists of the city's busiest radial and orbital routes.

Figure 6.1: Transport for London Road Network



Source: TfL

Whilst they account for just 5% (580 km) of London's total road length, the strategic nature of these roads means that they carry over 30% of London's traffic and, because of the high economic value of the trips made on them (e.g. for commuting, commercial freight distribution, etc.), they are estimated to account for over 40% of gross value added (GVA) of road-related movement across the whole city.

Secondly, as the strategic Traffic Authority, TfL also has powers to ensure the free movement of people and goods across a further 500 km of local borough-owned principal roads ('A-roads'), controlling the nature of both temporary and permanent traffic interventions, and funding capital schemes.

Finally, through its operation of the London Streets Traffic Control Centre (LSTCC) – and the maintenance, operation and management of all 6,000 sets of traffic signals on all of London roads – it is effectively responsible for the 'real-time' day-to-day operation of the entire road network, and for ensuring that traffic (in all its guises) continues to flow.

The city already has some of the most intensively used road space in the country, if not the world. Lacking the expansive boulevards of Paris, or the grid road system of New York, its largely medieval road network is already about 40% more densely trafficked than that of any other UK conurbation, and accounts for around 20% of the country's severe traffic congestion. Of course this level of usage is, in part, down to London's continuing success as the engine room of the UK economy; however, the congestion it creates is also a significant drain on economic efficiency, estimated to cost the city's economy at least £2 billion every year in lost productivity (according to TfL Roadspace Management).

Around three quarters of this congestion can be considered as 'demand-related' (i.e. arising from greater demand than the network is capable of coping with, particularly during peak hours). The remaining quarter arises from disruption caused by either 'planned' or 'unplanned' events, incidents and other interventions on the system.

2 Transport for London's Network Operating Strategy

TfL's basic network operating strategy is to manage/influence overall demand; attempt to maximise the availability and capacity of the network; and balance often conflicting demand between different types of road-space usage (cars, buses, pedestrians, cyclists, freight vehicles and the urban realm) while, at the same time, minimising disruption caused by both planned and unplanned events.

2.1 Minimising 'demand-related' congestion

In terms of managing and influencing demand, TfL has invested significantly – and continues to do so – in the expansion and improvement of the public transport network, as being the most efficient way of moving large numbers of people around the city. As a result, since TfL was created in 2000, rail and bus usage has grown significantly (the latter by 60%) and there has been a 9% modal shift away from private car use. However, in parallel to this, TfL has also been investing significantly in measures to extract more performance out of the road network itself.

Every year TfL reviews and refines the traffic signal timings at over 1,000 locations. Over the last five years this has resulted in an average 7.2% reduction in traffic delays across 5,029 traffic junctions. On top of this, the organisation has been investing in expanding its dynamic traffic signal technology, SCOOT (Split Cycle Offset Optimisation Technique). This is a computer-controlled traffic signal system which monitors real-time traffic flows on all approaches to junctions where it is installed, making over a quarter of a million decisions an hour to continually optimise flow, not only across individual junctions, but across the network as a whole. Since 2008, SCOOT has been installed at a further 1,000 locations across the city (on top of around 2,000 pre-existing sites), meaning that over half of all London's traffic signals are now so equipped. This investment has been shown to reduce traffic delays across junctions by an average of 12%.

TfL has also developed 'Pedestrian Countdown at Traffic Signals' (PCaTS), a system that provides dynamic information for pedestrians at traffic signals to show them how long they have available to safely complete their road crossing. Apart from significantly improving the pedestrian experience at the 283 locations where this technology is now installed (with 83% of all pedestrians and 94% of mobility-impaired pedestrians reporting a positive experience), because it enables more efficient use of the pedestrian green-man phase, PCaTS has also delivered reductions of up to three seconds (per vehicle) in journey times for vehicular traffic.

Finally, in order to effectively monitor overall road performance and to prioritise the development of measures to improve traffic flow and journey time reliability, on the TLRN itself TfL has developed a corridor management approach, appointing, for each one of its 23 routes, individual corridor managers who are charged with optimising the performance of their route. Journey time reliability (consistently highlighted by both private and commercial road users as the most important measure of road network performance) is measured on a continuous basis by around 450 sets of ANPR (automatic number plate recognition) camera pairings, and is reported monthly to ensure that network performance is optimised on an ongoing basis.

The cumulative result of this activity has been that, in the two-year period from 2010/11 to 2012/13, journey time reliability on the TLRN increased by around 1%, and traffic speeds increased by approximately 6.5%.

2.2 Minimising disruption from planned events

Planned events on the road network (highway works, utility roadworks, sporting/leisure/ceremonial events and so on) are responsible for around a quarter of non-demand-related traffic disruption; the majority of this is roadworks-related.

To minimise the impact of these works, the Mayor and TfL have implemented a number of key initiatives. These include the development of a joint Code of Conduct and 'Roadworks Pledge' with the major utility companies operating in London, and the implementation of the formal 'London Permit Scheme' (LoPS) for roadworks on the TLRN and on local roads in all 33 London boroughs.

In addition to this, on the very busiest parts of the TLRN, TfL has introduced the country's first 'targeted and avoidable' lane rental scheme for roadworks. This seeks to incentivise works promoters (including both utility companies and its own highway works managers) to avoid digging up the city's busiest roads at the busiest times by imposing punitive 'carriageway rental' charges of up to £2,500 a day if they do so. This has seen the proportion of utility roadworks carried out 'out of peak hours' on these roads increase from around 30% to over 90% (and Highway Authority works by 99%), helping to save approximately 2,700 days of disruption across London every year.

Overall, between 2010/11 and 2012/13, these measures cumulatively reduced recorded serious and severe disruption on London's road network by 46%.

2.3 Minimising disruption from unplanned events

Around three quarters of non-demand-related traffic disruption is, however, related to what are termed 'unplanned' events. The main contributors are road traffic collisions, vehicle breakdowns, and utility and highway authority emergency works (burst water mains, gas leaks, pothole repairs, etc.).

Whilst there is only a limited amount that any highway authority can do to stop these events occurring in the first place, there is a lot that can be done to minimise their impact once they do occur. TfL's approach focuses around three priorities:

- early incident detection;
- rapid response and 'clear up'; and
- effective management of traffic in the vicinity of such incidents.

In terms of early incident detection, TfL's LSTCC operates 24 hours a day, 365 days a year. It owns, or has access to, around 5,000 road-related CCTV cameras, including some with automatic incident detection equipment that can detect when traffic stops moving. LSTCC is co-located with both the London Buses main control centre (CentreComm) and the Metropolitan Police Traffic Operation Control Centre (MetroComm), both of which feed in continuous information about network performance from around 8,000 bus drivers and almost 2,500 dedicated police and community support officers working 'on the ground'.

Once incidents are identified, joint working ensures the earliest possible assignment of whatever resources are needed to resolve the incident (emergency services, highway or utility company contractors, etc.). Over the last few years, joint monitoring and reviews of how responses are handled has led to some substantial reductions in the length of disruption for certain types of incident. For example, the joint 'Roads Reopening Protocol' adopted between TfL and the Metropolitan Police for dealing with the response to serious road traffic collisions has effectively halved the average time taken to reopen roads from over eight hours to around four. Closer working between 'on the ground' teams and control centre staff has also led to ongoing performance improvement on key strategic corridors such as the Blackwall Tunnel, A40, North Circular and Marylebone Road/Euston Road, which account for a substantial proportion of overall network disruption due to their high traffic volumes and/or the lack of alternative routes available when incidents do occur.

While incidents are ongoing, effective operational management can limit the scale of the disruption around them. The LSTCC has the direct ability to control the timings on around 3,000 sets of traffic signals and can therefore intervene to ‘unblock’ junctions and alter signal timings to keep traffic moving (although the real mark of operator skill is actually knowing when *not* to intervene, as the dynamic SCOOT technology referred to earlier will often do this more effectively than any manual intervention).

Finally, a key part of managing incidents is getting timely and accurate information out to customers. There are effectively three opportunities to do this:

- firstly, before the start of their journey, when they still have the opportunity to change the timing (as well as the route) of their journey to avoid incidents and other congestion – for example through accurate information on the Internet, TfL’s live traffic news Twitter feed (which now has over 225,000 followers), the media and/or satnav;
- secondly, once in their vehicle, principally through radio broadcasting and real-time satnav updates; and
- lastly, through roadside information by means of over 140 permanent variable message signs and (for longer-duration incidents) around 30 mobile units that TfL can rapidly deploy in the event of major incidents.

This is the last point at which TfL customers have the opportunity to avoid unplanned incidents, and therefore be part of the traffic solution, before they hit the back of the queue and effectively become part of the problem that traffic operators are trying to solve!

3 Future challenges

All of these developments over recent years have undoubtedly been to the significant benefit of the road user; unfortunately, the challenge we face is not a static one. London is growing – growing in population (with an estimated 2 million more people predicted to be living in the city by 2031); growing economically (with an estimated 14% growth in employment by 2031); and growing in terms of overall transport demand (with an additional 5 million more trips expected to be made every day by 2031 on top of the 26 million trips already taking place daily).

All of this, together with increasing aspirations for the road network to play an enhanced role as a provider of high-quality ‘place’ facilities as well as simply ‘movement’ functions, is placing ever more (often conflicting) demands on what is essentially a finite road network.

Finally, having now transformed the public transport experience across the city, in 2012 the Mayor committed TfL to doing likewise for cycling. As a result, TfL is delivering a substantial programme of dedicated cycling infrastructure (which will inevitably take road space away from other modes of transport) and to achieving a 400% increase in overall levels of cycling by 2026.

3.1 The Roads Task Force

To address this challenge, in 2012 the Mayor of London, Boris Johnson, appointed an independent Roads Task Force (RTF) to consider how to:

- keep people and goods moving;
- balance conflicting demands for finite road space;
- transform the environment for cycling, walking and public transport – including in terms of safety; and
- facilitate all the activities that a world city like London needs.

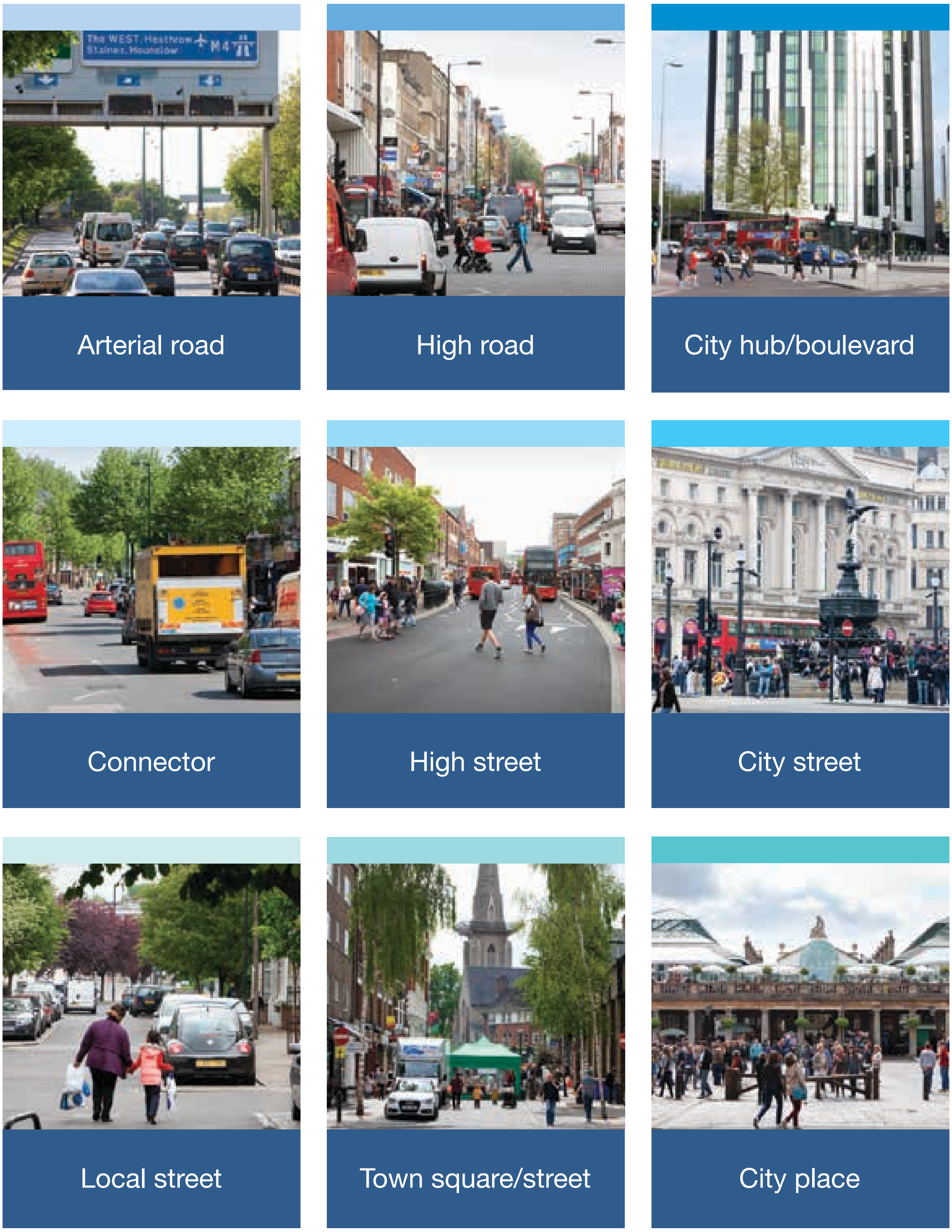
The RTF reported in June 2013. Its vision was for a great city, with vibrant spaces and a reliable efficient transport system, enabling access by sustainable modes to service its needs. Its recommendations included:

- adopting a 'street types' approach to prioritising the use of road space;
- innovating so as to more flexibly use existing capacity;
- improving engagement in order to increase consensus about how to balance conflicting demand; and
- improving governance to enable infrastructure to be delivered more efficiently.

In response, TfL set out its vision for keeping the city moving and supporting economic and population growth, adopting the RTF's key proposals as identified above and committing itself to spend £4 billion over the next ten years (which is double the previous levels of highway-related transport infrastructure investment). This money will pay for around 70 major highway enhancements; transform cycling; improve road safety; ensure that our road assets are fit for the future; and, through the enhanced use of technology, keep London's traffic moving well into the future.

In adopting the 'street types' approach to prioritising the use of road space, TfL has recognised that a 'one size fits all' approach to road user priorities is not appropriate in a city as large and diverse as London, and that there is an implicit need for different roads to provide a different balance between competing usage, dependent on their role and location. The nine classifications of street type, together with their relative 'weighting' towards either 'movement' or 'place' function, are set out in the table below. They effectively provide a high-level template for the maximisation of capacity across all road-space usage into the future.

Figure 6.2: Street types in London



Source: TfL, Roads Task Force

One of the most significant uses of this prioritisation approach is likely to be in making decisions on how best to redesign and potentially simplify the network, building on recent high-profile schemes such as the changes to the road layout in Piccadilly, which restored two-way traffic on Piccadilly itself, on Pall Mall and on St James Street in the heart of Westminster, and the removal of the Aldgate Gyratory which had a similar effect in the City of London.

Partly to support the delivery of this infrastructure programme, Surface Transport itself (the part of TfL that looks after streets, buses and everything else that it operates on the road network) has undergone a substantial reorganisation, moving from a structure based on its modal components (streets, buses, etc.), to a functionally based one built around integrated Asset Management, Project Management and Road Space Management directorates capable of minimising governance bureaucracy and maximising the operational value of the road space available, the assets employed and the projects delivered.

3.2 The Mayor's cycling revolution

After buses, cycling is most 'space-efficient' form of passenger road transport. It therefore makes sense that, having transformed the bus network, TfL should now seek to maximise the potential of cycling for moving people around London's increasingly crowded streets. Much has already been achieved: cycling levels on London's major roads are already more than double what they were ten years ago and, on some central London streets, cyclists now make up between 20% and 30% of traffic during peak periods. However, the Mayor's vision is to do much more, transforming London into 'the best large cycling city in the world', delivering a fourfold increase in cycling by 2026 (compared to 2000).

A large programme of fully segregated 'Cycle Superhighways' is planned on strategic road corridors, along with an extensive network of 'Quietway' routes along more minor roads and a 'Central London Grid' of designated cycle-friendly routes in the heart of the city. All of this will significantly rebalance the availability of road space in favour of cycling. TfL's challenge, apart from delivering this infrastructure, will be to keep other modes of traffic (particularly buses, freight and pedestrians) moving as well.

3.3 The use of technology

As we have seen, technology is already playing a significant part in keeping the city moving on a daily basis. It will need to do this even more so in the future. During the London 2012 Olympics we saw the first large-scale use of what was termed 'active traffic management' across the city – using dynamic traffic signal technology to proactively regulate flow across a wide area of central and inner London to balance conflicting demand for road space between Games traffic (and road-related sporting events) and general traffic. What TfL learnt from the Games is now being developed on a much wider scale to rebalance the distribution of traffic as these physical changes take place. Significant further traffic signal investment is being made, with a further 1,500 SCOOT-enabled sites planned by 2016. TfL's fully detailed 'One' model, developed for the Games to provide a complete operational model of central and parts of inner London (linked directly to the SCOOT system, to enable rapid and detailed operational planning across a large number scenarios), is now being developed across the whole of the city.

Significant amounts of money are being invested in further bus priority, much of which will be 'intelligent' or technology-related. For example, existing 'bus hurry call' technology at traffic signals works well when used in conjunction with conventional timetabled bus services, where the traffic signal systems can easily work out whether a bus is running early or late (against the timetable) and prioritise accordingly. However, most bus services in London are 'high frequency', with services operating every few minutes, and therefore a fixed timetable is of little relevance to either passengers or bus operators.

London Buses uses a single technology platform, 'iBus', a GPS-based automatic vehicle location system that is installed on every vehicle. Using this operational management technology, bus operators ensure that service reliability is maintained by managing vehicles to maintain even headways. Drivers have in-cab displays showing their relative headway, and service controllers continuously monitor their routes and the locations of individual vehicles, communicating directly with drivers to correctly space vehicles. However, when a traffic light controller receives a bus hurry call from an approaching vehicle, the traffic signal technology has no way of knowing whether the bus is ahead or behind schedule, only that priority is requested. When buses approach on different arms of a junction, it cannot therefore decide which one it should prioritise.

To overcome this, TfL is now working on linking SCOOT with iBus technology, so that the traffic signal technology will not only be able to understand whether a bus is running early or late and prioritise accordingly (assigning what is known as 'differential priority'), but will also help optimise the spacing of vehicles on routes in conjunction with the management of the traffic itself.

In terms of the day-to-day incident management on the network, TfL's ambition is to use its increasing data awareness to detect incidents faster and then use its developing analytics and modelling capability to simulate, in near real time, the likely impact over the immediate short term (e.g. the next half-hour). This will enable the SCOOT system itself to automatically devise traffic signal plans that minimise the impact of the incident on traffic flow. This will not only minimise incident-related disruption but also reduce the amount of manual interventional necessary to keep the city moving. The use of technology is not limited to vehicular traffic movement. As we have seen, the development of PCaTS has already brought tangible benefits to pedestrians. TfL is now also developing 'Pedestrian SCOOT', linking the remote detection of pedestrians waiting on the kerbside directly to the operation of the traffic signals themselves. This will be able to automatically extend green-man times when large numbers of people are waiting to cross, or even eliminate them when no one is waiting on a particular junction arm, reducing the overall cycle time and therefore the amount of time that people waiting on other arms have to wait to cross the road. Apart from improving the overall efficiency of junctions, this is likely to lead to significant safety benefits, through reducing pedestrian frustration (from having to wait longer to cross) which currently leads to a strong tendency for people not to wait for the green-man phase and cross anyway (typically, 85% of pedestrians will cross within 15 seconds of arriving at the kerbside, regardless of the traffic light phasing).

In the longer term, TfL is looking at how it might combine these technologies to eliminate entirely the need for 'all red' junctions (where traffic on all legs of a junction is halted to allow pedestrians to cross all legs at the same time). This is currently the most inefficient form of signalised control. London has at present around 500 such junctions, so finding a solution to this problem has significant potential to both keep traffic moving and provide faster crossing times for pedestrians.

There has also been increasing discussion in recent years about the role that cooperative vehicle technology and, ultimately, even driverless vehicles could play in the future management of the road network. During the London Olympics, TfL worked with BMW (provider of official Games Family vehicles) to test out technology linking their vehicles directly with the traffic signal system to enable them to moderate their flow to coincide with the timing of the lights themselves. This was a kind of automated 'green wave' technology, which minimises the amount of time the vehicles had to wait at red traffic signals. The results of this have encouraged TfL to develop a long-term workstream looking at the development of cooperative vehicle technology and the role that it can play in keeping traffic moving.

3.4 Further demand management?

In spite of all of these developments, the pace at which the city is growing means that they are unlikely to be enough on their own to meet the scale of the mobility management challenge London is facing. Managing levels of overall demand, either by continuing to invest in further public transport capacity, or influencing modal choice and the timing of journeys are likely to be essential.

One particular challenge in this regard is freight traffic, which currently makes up a significant proportion of peak-time traffic in central London. Historically, environmental measures such as night-time lorry bans aimed at controlling noise levels in residential areas have often deliberately pushed delivery traffic into these hours. Again, lessons learnt from the Olympics, when TfL worked closely with the freight industry to retime and 're-mode' freight brought into the city during the Games (including the trialling of quiet night-time deliveries), has proved that much more can be done in this regard to minimise the impact of commercial deliveries on peak-time traffic congestion – to the mutual benefit of other road users, the industry itself, and its customers. TfL is now therefore working more closely than ever before with the freight industry, the construction sector (one of the single biggest component parts of daytime freight movement) and London boroughs to understand how much can eventually be achieved in this regard.

4 Conclusions

The era of 'predict and provide' road building is now long gone in mature urban conurbations such as London. However, predicting, managing, influencing and prioritising demand, and maximising the operational efficiency of the road network, will continue to present ever greater challenges to transport planners, engineers, traffic modellers and all those involved in keeping London moving.

In the short and medium term, apart from in a few specific locations (such as river crossings in east London), the opportunities for large scale new infrastructure delivery is going to be limited. Maximising the availability of existing road infrastructure to keep the city moving and enhance quality of life is going to inevitably focus on increasing the efficiency with which we use what we already have. Both technology development and behaviour change policy measures therefore have a significant role to play. Active traffic management and other developments in traffic control (e.g., more effectively targeted enforcement, better road user information) will take us some of the way there. However, effectively influencing modal choices, promoting the most space efficient modes of transport (buses and cycling) and methods of freight delivery will become an ever more essential part of the overall transport management equation.

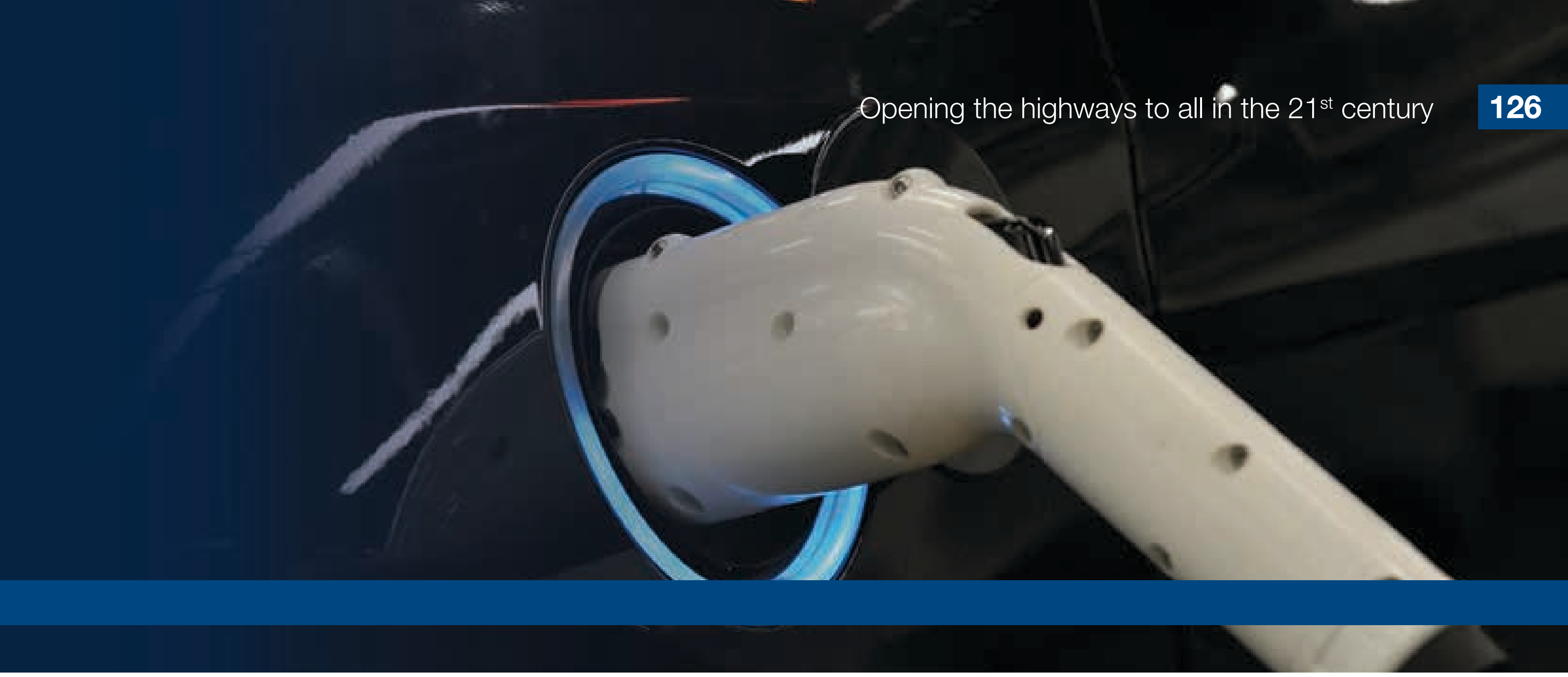
In the longer term, there are opportunities to develop more radical infrastructure and technology solutions – such as greater use of urban road tunnels – to free up road space on the surface and successfully integrating developing vehicle technology with traffic management systems. However, ultimately the task of urban road network operation will continue to be one of balancing essentially conflicting use of the road network to optimise its social, economic and environmental benefit to the city as a whole.

It is therefore clear that the next few years are going to be an exciting time for those involved in the management and development of London's road network.

7. Opening the highways to all in the 21st century

– a manufacturer's view, Ford

It's just over one hundred years since Henry Ford revolutionised personal mobility with the introduction of the Model T – regarded as the world's first mass-produced automobile. Vehicles continue to develop at an unprecedented rate, as do all the technologies associated with them. Even a visionary like Ford would have struggled to imagine how the world would be transformed by the mass-production vehicle.



1 Sustainable technologies and alternative fuels

In the earliest years of our industry, automotive engineers experimented with a variety of methods for powering vehicles, including electricity and what we would now refer to as biofuels. The internal-combustion engine (ICE) using petroleum-based petrol and diesel rose to the top fairly quickly, and has been the standard vehicle power source for the past hundred years. In a way that is reminiscent of those early years, we are now in a period of intense development and adoption of new vehicle technologies and fuels. At this time, however, there is no single winner in the race for the vehicle of the future.

That is why Ford is taking a 'portfolio approach' to developing sustainable technologies and alternative fuel options. Our goal is to provide diversity in fuelling options, in order to meet customers' differing needs, while at the same time improving vehicle energy efficiency and long-term sustainability. We are thus providing customers with a range of affordable, fuel-efficient vehicles, advanced powertrains, and alternative-fuelled vehicle options – including fuel-efficient EcoBoost petrol engines, advanced diesel engines, hybrids, plug-in hybrids, all-electric vehicles and alternative-fuel vehicles. We call this approach the 'power of choice', because it allows customers to choose the vehicle that best meets their driving needs.

To deliver this 'power of choice' strategy, we are developing global vehicle platforms that are compatible with a wide range of fuels and powertrain technologies. This allows us to offer a portfolio of options to our customers, target specific options to regions where they make the most sense, and evolve our vehicles as technologies and markets develop. Global vehicle platforms that have 'plug-and-play' compatibility with a wide range of technologies will also allow us to make the range of fuel and powertrain options available more affordably. For example, we have introduced an all-electric Ford Focus, a hybrid electric Ford CMAX and the CMAX Energi plug-in hybrid – all built on our global C-platform.

We believe that traditional petrol- and diesel-powered vehicles with ICEs will continue to be a major part of the mix for quite some time. So we are working to improve the fuel efficiency of the engines and transmissions of our current vehicles, along with every vehicle subsystem.

Also, we currently produce a range of flexible-fuel vehicle models across our global markets; these vehicles can run on either standard petrol or E85 (a blend of 85% ethanol and 15% petrol). In addition, biofuel availability is expected to increase globally. In Europe, the EU's Renewable Energy Directive mandates that 10% of energy in the transport sector must come from renewable fuels by 2020. Our flexible-fuel vehicles, which are provided at little or no additional cost, allow consumers to choose fuels based on availability and price.

In the longer term, hydrogen may emerge as a viable alternative fuel. Hydrogen has the potential to diversify our energy resources and lower life cycle greenhouse gas (GHG) emissions, if low-carbon hydrogen production becomes feasible. To prepare for this, we are developing technology to power vehicles with hydrogen fuel cells. In addition, we are working to pair hydrogen fuel cell technology with vehicle electrification technologies to maximise the sustainability benefits of both technologies.

We have also been developing a range of electrification technologies. Consumer interest in and demand for electric vehicles (EVs) – which include hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and pure battery electric vehicles (BEVs) – have been growing. And recently the rate of growth has increased significantly. To meet this growing demand, most major car manufacturers now offer some form of EV. They form an important part of Ford's overall sustainability strategy helping us to deliver on our commitment to reduce the carbon dioxide (CO_2) emissions of our fleet. To do this, Ford are electrifying global vehicle lines rather than limiting development to a single, special EV model. This allows our customers to choose from a variety of EV powertrains – including three HEVs, two PHEVs and one full BEV – in a range of vehicle segments, including saloons, utility vehicles and luxury vehicles.

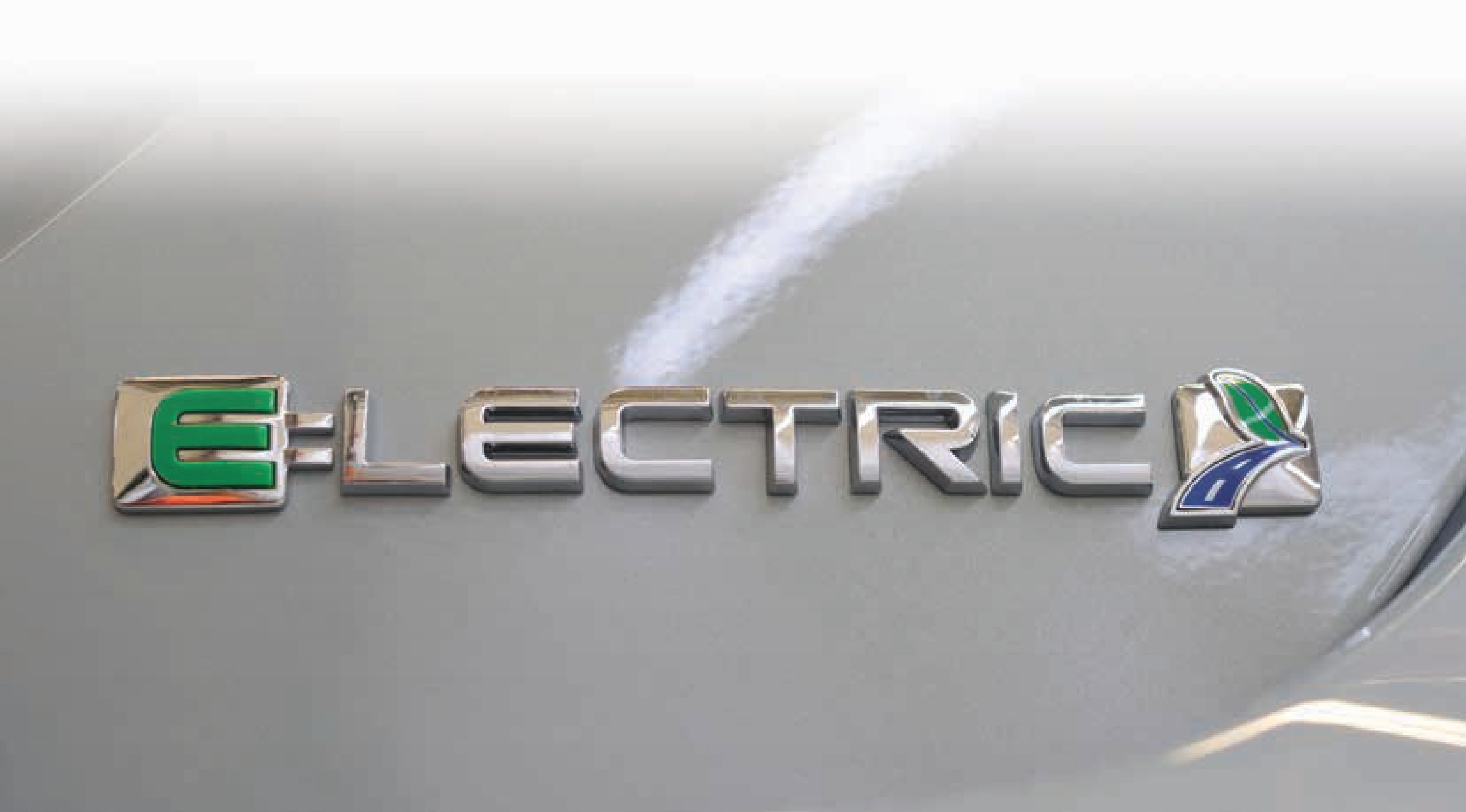
EVs offer many advantages to consumers, but they may sometimes require owners to adjust their travel routines and driving habits, and may cause some new considerations to arise in regard to how a driver uses a car. For example, BEV drivers have to plan for their car to have enough charge to get to the next destination. BEV and PHEV drivers have to consider where they will charge their vehicles. Even HEV drivers can make changes to their driving routines to maximise the efficiency of their vehicles.

Despite the advantages of EVs for the consumer and for the environment, and their falling cost, many challenges remain. For example, even though the purchase prices of EVs (especially HEVs) are beginning to become more competitive, the price premium over conventional vehicles remains significant.

In addition, consumers continue to have concerns about the driving range of BEVs. And for EVs to achieve their full potential for cutting lifecycle automotive GHG emissions, low-carbon electricity generation must make up a greater part of the total energy supply, and EVs must become functioning parts of 'smart grids'. Moreover, battery technologies are still evolving, and the cost of new-generation batteries remains high. We are also assessing supply-chain issues associated with the materials needed to manufacture batteries, including the availability of lithium and rare earth elements. Furthermore, customer demand for EVs must continue to grow if these vehicles are to have a significant effect on overall transport-sector emissions.

In addition, the development and diffusion of EV technologies presents a global challenge. It will take a collaborative approach involving car manufacturers, battery producers, suppliers, fuel producers, utilities, local authorities, educators and researchers, as well as policymakers, opinion shapers and consumers, to help us make the transition and realise the full benefits of electrification. We are collaborating with all of these players to develop an 'electric vehicle ecosystem' that supports and enhances the operation of EVs, and increases their benefits to both customers and the environment.

Ford's plan calls for strategic partnering with key suppliers who provide technical expertise, financial solidity and a collaborative spirit. We believe that working with a range of partners will allow us to gain greater understanding of the connectivity of vehicles to the electric grid, promote the necessary infrastructure, and bring down the costs of the technology to make it more accessible for consumers. We are partnering with companies that are already the best in their fields, instead of attempting to recreate products, services and technologies internally, so as to offer customers the best possible suite of EV-related products, services and technologies.



Anyone who owns an EV can attest that the experience of driving one is essentially the same as that of a 'normal' vehicle powered by an ICE. Certainly no special skills are needed to operate EVs such as hybrids, plug-in hybrids or pure BEVs. Under the bonnet, however, EVs are, in fact, different from non-electrified vehicles in at least one important respect: they contain a battery with 300+ volts of power, whereas a normal vehicle has just one 12-volt battery. And that means that first responders – the firefighters, police officers and emergency medical technicians who show up at the scene of a crash site – may indeed need some special knowledge and skills to be able to safely address a vehicle crash involving an EV. To address this need, we and other EV manufacturers have developed special Emergency Responder Guides for each of our EVs. These guides include information on how to identify a Ford EV, locate the high-voltage system, disconnect it, and move and store the disabled vehicle, among other key tasks. Also, over the years, we have actively supported firefighters' hands-on crash-response procedure training events, through the donation of EVs and the attendance of Ford technical personnel.

2 Vehicle safety

At Ford, we have a long history of developing and implementing new innovations that improve the safety performance of our vehicles. Back in 1955, for example, Ford became the first car manufacturer to offer factory-installed safety belts. That legacy of innovation continues today. We design and manufacture vehicles that achieve high levels of vehicle safety for a wide range of people over a broad spectrum of real-world conditions, using the Haddon Matrix to take a holistic view of the factors that may affect vehicle safety. (The matrix was developed by William Haddon, a former administrator of the US National Highway Traffic Safety Administration, and also former president of the Insurance Institute for Highway Safety.) The Haddon Matrix illustrates how traffic safety can be the product of complex interactions between the driver, the vehicle and the driving environment.

The Haddon Matrix is used to look at crashes in terms of causal and contributory factors, including human behaviour, vehicle safety and the driving environment. Each factor is then considered in the pre-crash, crash and post-crash phases. In the pre-crash phase, the focus is to help avoid the crash. In the crash and post-crash phases, the primary objective is to help reduce the risk of injury to occupants during and after a collision. In the post-crash phase, for example, the goal is to minimise the amount of time that elapses between the crash and when help arrives.

Driver behaviour is a key contributory factor in many vehicle crashes. We at Ford have developed and support an array of programmes and technologies that help to encourage safer behaviour on the roadways, for both experienced and novice drivers.

Smartphones and other portable electronic devices are commonplace in our modern society. The public has become accustomed to using these devices everywhere – at home, on the street, in restaurants, at the office, while shopping and – of most interest to Ford's safety researchers – while driving. Indeed, studies indicate that approximately 10% of drivers are using their mobile phones at any given time, which has heightened concerns about the potential for driver distraction.

For over a decade, Ford has been focused on the issue of driver distraction, and we've taken steps to enhance driving safety for those who use mobile phones and telematics devices while driving. Ford's SYNC technology, our voice-activated in-car connectivity system, has been shown to significantly enhance the ability of drivers to attend to the driving task while using mobile phones and music players. Ford researchers found that using SYNC substantially reduces drivers' eyes-off-road time and improves lane-keeping, speed maintenance, and object and event detection response times, when compared to using handheld devices for the same tasks.

A variety of Ford technologies, in addition to each vehicle's handling and braking capabilities, can assist drivers by helping to control the vehicle or alerting the driver to potential collisions. Moreover, these technologies can support routine driving tasks by improving comfort and reducing demands on the driver. Driver assistance technologies will continue to advance to include semi-automated capabilities, providing drivers more assistance in certain situations, such as when changing lanes, in traffic jams or on freeway trips. The driver will always remain 'in the loop', able to take control if required. The radar- and camera-based technologies that we offer today are a first step toward our vision of automated vehicles that still offer the driver this control. We have also been working on separate technologies that will enable vehicles to communicate with one another and with roadway infrastructure. Automated and connected vehicles will help to make driving safer, reduce traffic congestion and lower emissions.

Many factors influence a vehicle's crash performance, including the design of the vehicle's structure (i.e. its ability to absorb impact energy) and the use of passive safety equipment such as airbags to supplement safety belts. Ford's commitment to advancing the state-of-the-art in vehicle safety includes research and development of technologies that further enhance occupant protection in a wide variety of crash circumstances. Ford is using more advanced materials than ever, including ultra-high-strength steels, plastics, composites and aluminium. Increased use of these materials helps us design vehicle structures with enhanced crash energy management while reducing overall vehicle weight – even as we add more features, equipment and safety devices. Safety belts remain the most important vehicle safety technology available. Ford brought to market the world's first automotive rear inflatable safety belts, which combine the attributes of traditional safety belt and airbag technologies to help further reduce the risk of head, neck and chest injuries for rear-seat passengers.

Safety regulations and public domain rating programmes differ around the world, and they are constantly evolving in response to various regional factors. The public domain rating programmes that perform vehicle crash testing and other assessments have regularly updated their testing protocols and evaluation criteria to reflect the needs of the region. Since 2011, several of these programmes have markedly revised their vehicle rating systems, making it increasingly difficult to achieve the highest ratings. The changes have also caused the testing protocols to become even more inconsistent and divergent between regions. Some of the changes include the addition of new assessment items (such as different-sized dummies in different seating positions), different or more stringent crash evaluation criteria, and greater emphasis on accident avoidance and driver assistance features. The complexities of these evolving programmes may initiate a demand for different vehicle technology offerings in different markets, which represents a major challenge for a global automotive company like Ford.

3 Challenges and opportunities relating to mobility

As we look at the megatrends listed below which are shaping the future, it is apparent that a business model built on private ownership of cars comes with inherent challenges, including increasingly diverse and fragmented markets for traditional car sales. We see this as an opportunity for companies which are able to respond to mobility needs in a creative manner.

- **Urbanisation**: By 2025, it is projected that at least 37 megacities will have a population of more than 10 million. The migration of rural populations to urban areas often outpaces infrastructure development, leading to overcrowded, substandard living conditions, and inconvenient, congested transport systems.

- **Congestion**: It's estimated that the average person spends five years of their life waiting in queues, six months of which are spent staring at a red light. Recovering even a fraction of this time is priceless. A 2012 report by the Centre for Economics and Business Research for INRIX found that traffic congestion in Britain cost the economy more than £4.3 billion a year; £426 million is wasted on fuel alone and £2.7 billion as a result of lost time (which equates to approximately £331 per commuter annually) (Cebr, 2012).

- **Built and digital infrastructure**: More congestion means greater impacts on roadways and other infrastructure, which will require different products and solutions from a coalition of stakeholders. As transport and utilities become more interdependent, collaboration must take place among manufacturers, energy/utility companies, and communications and information technology companies.

- **Climate change**: Climate change and associated regulation is leading to new vehicle standards and increased costs. However, the benefits of more stringent vehicle fuel economy and GHG standards are eroded as vehicles spend more and more time idling in gridlock conditions.

- **Population**: Different regions of the world are experiencing opposing population trends. Among the more developed countries, only the USA is growing in population; Europe, Russia and Japan are all shrinking. Regions of Africa and Asia are growing in population and will have large numbers of young people. But by the middle of this century, most of the world will be much older on average. With most people living in urban areas, more and different forms of mobility will be needed to support independent living for seniors, the disabled and young people.

- **Social inequality**: The gap between rich and poor creates enormous needs for innovative, affordable mobility solutions that meet human needs and help people build a better way of life. Unequal access to transport often limits the opportunities available to those most in need. Better mobility is part of the solution to unemployment and income disparities.

As we look to 2020 and beyond, there are a number of changes we already can see: the global population is growing; life expectancies are increasing; and today's emerging markets are becoming the epicentre of growth.

The Ford mobility vision aims for a holistic approach, blending smart transport with intelligent vehicles and transport systems that are interconnected through a global technology network. We envision a radically different transport landscape in which pedestrian, bicycle, private car, commercial and public transport are woven into a connected network that saves time, conserves resources, lowers emissions and improves safety. We know we must view the car as one element of a broader transport ecosystem and look for new ways to optimise the entire system through automation, electrification, services and other technologies. Consider that there are about 7 billion people in the world today. Yet within our lifetime, that number will approach 9 billion. Also, there are more than 300,000 people over the age of 100 in the world today. By 2050, that number could surpass 2.5 million. There will need to be a focus on finding ways to design vehicles with these customers in mind. At the present time, there are about 1 billion vehicles on the road worldwide. And it took roughly a hundred years to get to this level – yet, with more people and greater prosperity, many experts believe that number will double in the next 20 years, and then possibly double again.

These challenges go well beyond inconvenience. If we look at the numbers and look at the state of our global transport infrastructure, it is not difficult to see a future in which the flow of commerce – and even the flow of health care and food delivery – are compromised. At Ford, we see global gridlock as more than simply an issue of business and economics – we believe it is a problem that could have a significant impact on the quality of human life.

We are already developing new business models and partnerships with this future in mind, in a way that is shifting the paradigm of what it means to be a car manufacturer. But no single company or industry will be able to solve the mobility issue alone. It is a huge challenge that will only be successfully tackled if governments, infrastructure developers and industry all collaborate on a global scale. The speed at which solutions take hold will be determined largely by customer acceptance of new technologies, as well as how quickly cities develop the enabling systems and infrastructure.

The last few years have seen technological breakthroughs, such as vehicle-to-vehicle communications, that we didn't think possible a few decades ago. Increasingly, Ford has become a technology company that makes cars and trucks, and we will continue to explore ways to leverage these technological innovations so we can tackle mobility challenges.

By 2050 we will have a true network of mobility solutions, and cars will probably look very different from how they look today. In view of this, we have set out what we call our 'Blueprint for Mobility'. We expect vehicle-to-vehicle communications, where vehicles will 'talk' to one another, transmitting safety messages; and vehicle-to-infrastructure technologies may enable improved safety, while allowing more vehicles to share the road. In-car mobile communications and driver interfaces will become more intuitive. The proliferation of digital maps and cell-based communications will provide better driver information and entertainment features, and will be able to proactively alert drivers to traffic jams and accidents. EVs will be more commonly used as a shared mode of transport for urban users. Vehicles will be parked at charging stations and may well get their power through solar panels, as does our C MAX Solar Energi Concept prototype.

At Ford, we believe that mobility challenges – in urban as well as in rural settings – require the same level of attention and determination that we have put into developing solutions for the environmental challenges faced by our industry. When it comes to environmental sustainability, we have been making great strides with new vehicle technologies, alternative fuels and vastly cleaner solutions.

A truly sustainable, long-term solution will require a global transport network that includes vehicle, infrastructure and mobile communications. We need cars that can communicate with each other, and with the world around them, to make driving safer and more efficient. This smart, connected system will tie all modes of travel into a single network linking public and personal transport together.

Ford was founded on the notion of opening the highways to all mankind, and we still believe in providing accessible, personal mobility for everyone. Our Blueprint for Mobility is based on an analysis of population growth, urbanisation and other key societal and economic trends. Our goal is to make mobility affordable in every sense of the word – economically, environmentally and socially – and provide seamless mobility for all. Everything in our Blueprint is achievable in the future based on existing technology. The key challenges are making the offerings affordable and attainable to all customers, and finding ways for all stakeholders – the car industry, governments, technology companies and more – to make the adaptations needed to the transport infrastructure.

Looking at the Blueprint in more detail, in the near term (to about 2020), Ford will be developing increasingly intuitive in-car mobile communication options and driver interfaces. There will be further development of projects such as the vehicle-to-vehicle warning systems currently being tested, and systems to proactively alert drivers to traffic jams and accidents. We will deliver a better-connected, safer and more efficient driving experience, with limited automated functions for parking and driving in slow-moving traffic, building on existing Ford features including Active Park Assist, Adaptive Cruise Control and Active City Stop. There will be further development and defining of new vehicle ownership models, as already demonstrated through Ford's marketing collaboration with Zipcar, the world's largest car-sharing and car club service, and our new car-sharing programme in Germany.

In the medium term (to about 2025), we expect to see the introduction of semi-automated driving technologies, including driver-initiated automated capabilities and vehicle platooning in limited situations, to provide improved accident avoidance and driver assistance features that always allow the driver to be in overall control and aware of the situation in case he or she needs to intervene. There will be significantly more interaction between individual cars on the road, through the utilisation of ever-increasing computing power and numbers of sensors in vehicles, potentially helping to reduce the number of accidents at junctions and enabling limited semi-automated and automated highway lane-changing and exiting. We expect to see vehicle-to-cloud and vehicle-to-infrastructure communications that contribute to greater time and energy efficiency by enabling vehicles to recommend alternative transport options when congestion is unavoidable, and to reserve parking spots at destinations. The emergence of an integrated transport network, featuring cars plugged into public databases, is anticipated, as are new city vehicle options, as more and more one-, two- and three-passenger vehicles are introduced to help manoeuvre on city streets.

Looking long-term (2025 and beyond), a radically different transport landscape starts to emerge in which pedestrian, bicycle, private car, commercial and public transport traffic will be woven into a single connected network to save time, conserve resources, lower emissions and improve safety. We will see the arrival of smart vehicles capable of fully automated navigation, with increased automated operating duration, plus the arrival of automated valet functions, delivering effortless vehicle parking and storage – plus the development of a true network of mobility solutions, with private vehicle ownership complemented by greater use of connected and efficient shared services, and completely new business models contributing to improved personal mobility.

4 New models of mobility

Ford are investing significant research and development resources in new models of transport, and helping to advance thinking about it. We are doing this through partnerships and pilot projects at several global locations. Some of these projects have focused on exploring how to deploy EVs as part of integrated mobility solutions aimed at creating “clean, green, smart and safe” cities. We believe that creative collaboration and innovative technologies and services can yield new solutions, and that these solutions can harness the benefits of mobility while reducing its environmental and social impacts.

Shared models of car ownership will also become increasingly important, especially in urban areas, where a peer-to-peer system of shared vehicles offers promising solutions. Electrification can enable more economical, more efficient and more environmentally friendly options. In addition, younger generations of consumers seem to have different relationships to cars that make them better suited to new models of mobility.

We have been involved in several car-sharing research projects that are designed to develop new models and methodologies for systems that integrate vehicle sharing and public transport systems. Many people around the world want the benefits of personal mobility, but don’t necessarily want to own a car. Car sharing offers an approach that can provide those benefits while reducing congestion and the environmental impacts of the private car.

According to a poll sponsored by Ford Motor Company, more than half of Europeans – 56% – would consider car sharing, either through a formal programme or through private arrangements. Drivers increasingly see car-sharing programmes as viable options, especially in dense urban areas where parking can be problematic and where public transport fails to meet all mobility needs. Ready and affordable access to a pool of available vehicles can provide on-demand transport flexibility.

As a company, we are committed to a collaborative and integrated approach to future mobility.

5 Vision for the future

At the same time as continuing to develop technologies that allow for more semi-automated capabilities, we have been working on separate technologies that will enable ‘connected’ vehicles – that is, vehicles that can communicate with one another and with roadway infrastructure using advanced Wi-Fi signals or dedicated short-range communications over secured channels. By communicating with each other and the world around them, these vehicles will form a key element of the integrated transport ecosystem we envision in our Blueprint for Mobility.

In our long-term vision of a future with vehicles that are both automated and connected, driving will be safer, traffic less congested and greenhouse gas emissions lower. Such vehicles will be able to warn drivers if their vehicle is on a collision path with another vehicle at a junction, when a vehicle ahead stops or slows suddenly, or when a traffic pattern changes on a busy highway. By reducing collisions, connected vehicles will ease traffic delays, which will save drivers both time and fuel. Gridlock will also be avoided through a network of connected vehicles and infrastructure that processes traffic information and suggests less-congested routes to drivers.

Admittedly, this vision will probably not be realised for many years yet. Many technological details remain to be worked out, and drivers will need to become comfortable with the idea of giving up some measure of driving control to their vehicle, which will not come easily. In order to progress from current technologies to our long-term vision of connected and automated vehicles, we are conducting collaborative research with a variety of public, private and academic entities.

In the 21st century, Ford defines mobility as accessibility for people, goods and services to go where they need or want safely, efficiently and affordably – providing a simplified and fun customer experience. Our goal is to make mobility affordable in every sense of the word – economically, environmentally and socially. We see a future of connected cars that communicate with each other and the world around them to make driving safer, ease traffic congestion and sustain the environment. By doing this, we can have an even greater impact on the next hundred years than we did in our first century.

6 References

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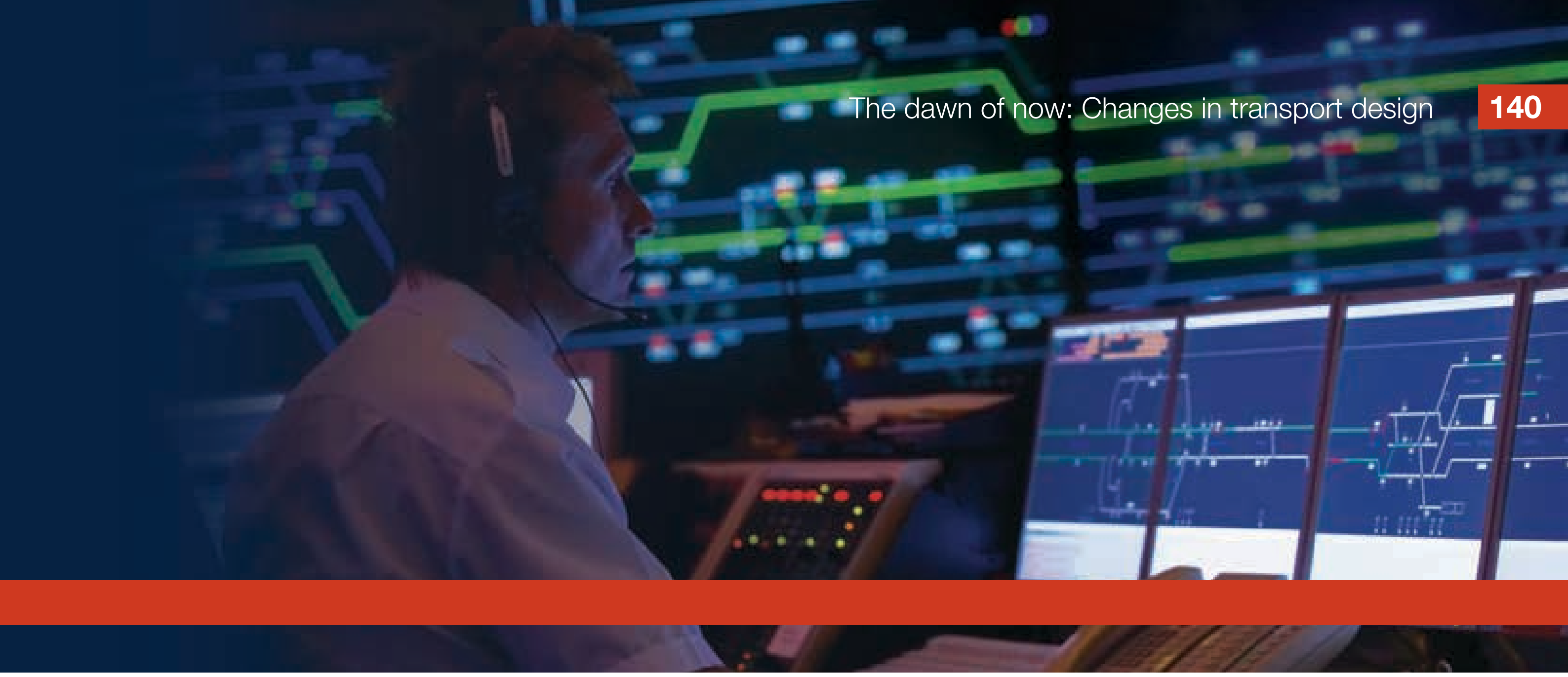
8. The dawn of now: Changes in transport design

– by Dale Harrow, Royal College of Art

When I look out of the Vehicle Design studio of the Royal College of Art (RCA) onto the streets of Kensington, it would be easy to feel that nothing has changed in 20 years. There is the usual matrix of vehicles – buses, cars, motorcycles, cabs, vans, trucks and bicycles – and the familiar mix of workers, commuters, tourists and families, all going about their business, in a street scene that looks much the same as it did two decades ago. Superficially, the only obvious change is that there is more of everyone and everything: it is clearly much busier. Nothing could be further from the truth. In the last 20 years technology has in fact significantly changed all our journeys.



On closer examination, the street scene *has* changed, either through initiatives such as road charging, road management through bus and cycle lanes, and restricted-use areas for the private car, or – perhaps the biggest and most recent transformation – digital connectivity. Look again. Everyone is connected to some sort of device: checking email, talking business, and accessing information. Digital connectivity is creating and reinforcing new services such as ‘Boris Bikes’ and car-sharing schemes. Apps for smartphones such as Hailo allow us to order taxis, and other apps let us know where the next tube train is or allow us to navigate through the city, whether as drivers or when connecting modes of transport as pedestrians. The city infrastructure is changing to meet new demands: there are new post-Routemaster buses, for which we can pay with smartcards, that use hybrid technology to reduce pollution and improve the environment, and continuously tell operating centres where they are; bus stops that use digital timetabling; and hybrid and electric vehicles with charging points.

The future is now. As a child of the Sixties, I believed the future would be supersonic, and we would all be driving flying cars and eating coloured pills for our meals. But we are now in an age where technology is all around us and we integrate with it in a seamless and homogeneous way. Data is everything. Google knows what we like, and Facebook knows who we are, while instant information and constant interaction gives us endless ways to connect and interact with the city and with one another.

Combined with the means to use data to manufacture and produce in new ways through rapid manufacturing (RM) and access to a truly worldwide consumer base, this offers new opportunities to develop differing types of vehicle and innovative ways of using services.

What does this mean for design? Designers do not work in a vacuum. They are a product of individual experience and a changing world. Vehicle designers have traditionally focused primarily on the exterior, and only then the interior of vehicles. We are now in a position where designers can still work across these traditional areas, but also be involved in the creation of interfaces, new materials and novel methods of production. Teamwork can bring together mixed skills, enabling engineers, technologists, social scientists and other professionals to collaborate with designers to pioneer the development of fresh approaches, in order to find new and exciting solutions for the dynamic urban transport landscape. Open-source design and social media can be used for public engagement in real time, to test solutions as they develop and as design becomes more democratic.

An RCA conference in 2000, *Moving On – the Future of City Transport*, brought together academics, industry and policymakers to discuss and develop new ways of finding solutions for this complex future. The conference predicted many of the changes in technology that are emerging, such as the autonomous vehicle. The findings became a template for research and the teaching of the Master of Arts curriculum at the RCA, to create the next generation of designers. Team working is part of the solution, and we work closely with the Helen Hamlyn Centre for Design (HHCD) at the RCA to develop new methods.

Technology is also influencing the process of creation. Moreover, that process is evolving from traditional sketch and physical models to a hybrid process that adds realistic animations, contextual images of potential solutions in-street, and highly detailed models, through the use of rapid prototyping (RP), which offers the opportunity to produce hard model outputs from computer data.

This digital connectivity of process and making with RP and RM will change the way we manufacture and purchase products. It is sometimes referred to as the fourth industrial revolution, after the harnessing of coal and steam, mass production, and automation.

We will be able to download data and produce objects from that data, or from sites such as Amazon. This allows customisation for a manufacturer, meaning that goods can be tailored to a sector or individual. Low tooling costs mean that volume is less important, so producing thousands of identical parts is no longer the only economic option – which, given the relatively low volumes associated with (for example) public transport, makes the need for only small numbers of parts less of an issue.

The RCA's MA curriculum brings together design, technology and policy to consider social change, alongside technological opportunity. This essay reviews the work of postgraduate students and staff to illustrate some of the ways in which design can solve problems, and to demonstrate how technology will continue to transform the city and our lives.

Technology manifests itself as an inter-sensory experience and a complementary part of our daily life. Technology will affect the self, the vehicle, the service and the system. Design lets us see, feel and touch, to create new meanings. If one golden age of travel is over, the next is just beginning.

1 The challenge

Creating an integrated transport system that offers mobility in the urban environment and is people-centred, safe and sustainable is the challenge that all cities face. The topic is at the forefront of government policy, because congested cities are inefficient, costly and diminish the quality of life of their citizens, workers and visitors. Countries across the world, including the UK, are investing to solve these problems, through initiatives such as the Technology Strategy Board (TSB) Transport Systems Catapult (TSC), which supports 'intelligent mobility', and the Government's autonomous vehicle programme.

One hundred years ago, travel in London was by foot or horsepower, and traffic moved at 12 mph. One hundred years on, congestion has reduced travel to below that speed in most major cities.

Industrial development and mass transportation are intimately linked. The dramatic growth of megacities, the decline of heavy industries and radical changes in living and working patterns are all creating new demands for transport and travel, both within and between cities.

In terms of transport problems, we all face the 'big three': congestion, pollution and energy consumption. Old modes of city travel, and the unrestrained use of motorcars, have reduced amenity values in our city centres and created tensions as infrastructure investment has lagged behind increased car use. Discernible everywhere, these tensions are nevertheless most evident in cities, and demand a rethink of vehicles and transport services for goods and people – a rethink that challenges the future viability of the private car as we know it, and moves toward a mixed economy, in which the boundaries between public, private and individual transport needs are blurred.

These tensions are seen the world over as new markets adopt mobility practices from the West. The private car offers freedom and mobility but, as we move further into the 21st century, the social, environmental and economic costs of almost universal car ownership are raising difficult questions.

Current and new technologies potentially enable high levels of integration, to create a seamless journey. The components of travel – foot, car, bus, taxi, train, and any other mode; individual and volume; private and public – can be programmed together holistically, with individual customisation and choice.

Technology is enabling innovations such as flexible car-sharing solutions (for example, Zipcar), while many cities are now offering bike-sharing services. There has been an increase in the number of electric bicycles and new hybrid forms of transport, often enabled by real-time internet-based services, accessible from any mobile device, giving the user greater flexibility. But there are even more opportunities for design and technology to work together to create effective new types of vehicle within the urban context.

The technology we have at present does enable the seamless integration of public and private transport, and of personal and communal forms of travel. We now have the possibility of technology delivering intelligent vehicles, communicating with intelligent roadways and with each other; and of individual customisation of both the journey and the interface with the system. The whole journey can now be planned as a complete experience, responsive to the travel and mobility needs of individuals – for example tourists in a strange city – and services can be booked on-the-spot or in advance, using smartphones and the internet. This delivers access and choice to the individual, along with high levels of integration, cost-saving and long-term sustainability.

Let us consider how technology will affect urban transport design through three filters: the self, the service (the vehicles) and the system.

2 The self

Ever more, ever faster than ever before, we are becoming urban dwellers. The global population is gravitating to cities. Since 2008 more than 50% (3.3 billion people) live in the urban environment. Forecasts see this rising to 70% by 2050 to almost 5 billion people.

We are living longer, getting older and travelling more, at a time when environmentalists talk of the need to dramatically reduce the global impact of human activity over the next 20 years. In developed areas such as Europe, Japan, and North America the population is ageing. The age structure of modern society is changing through medical advances, and as the population declines due to low birth rate. Within the next 20 years, in the developed world, half the adult population will be aged 50 or over with considerable increases in the number of retired people and a dramatic growth in the 80+ age group.

Mobility is a key factor in life-quality. Meeting friends and visiting relations, shopping, recreational and educational activities, are all essential parts of an active life.

Car ownership and the driving of cars is almost universal in the UK, and have provided the link to these activities. If car ownership or use in cities is restricted, public transport becomes a vital link to enabling people to maintain independent living.

There are lessons for the car industry in designing vehicles for the ageing driver – clear graphic information for displays, and haptic (relating to or based on the sense of touch) controls giving feedback, or better door apertures, for example; but, with a growing emphasis on autonomous vehicles, solutions for elderly and disabled drivers could, and probably will, be delivered by advancing technology.

We are connected and interconnected as never before. We are all linked through our adoption of digital media. This is having an impact on every aspect of our daily lives. It is difficult now to imagine a world in which we shop, socialise, work and travel without connectivity. This is changing our relationship with the city, and how we operate both within and outside it. The decline of the high street as a retail and social hub is down to online shopping, and by-products include the growth of White Van Man and 'just-in-time' truck delivery to out-of-town hypermarkets.

As the Boomers are ageing, the Millennials –the so-called 'Generation Y' born in and since the 1980s – are meanwhile reaching maturity. This generation, with its traits of confidence and tolerance, but also its sense of entitlement and digitally encouraged narcissism, is comfortable with communication, media and digital technologies, and less concerned with wealth and ownership than it is with experience. Why own when you can download? This attitude will change ownership models, and can already be seen in the lack of new car sales to this segment and the growth of car-sharing schemes.

Case study 1: The Connected Car – sustainable and inclusive mobility: Norwegian car company Think / Filip Krnja / RCA Vehicle Design / HHCD

Image source: Filip Krnja

Despite the transition to the digital age, the layout of car cockpits has not changed significantly for decades. As a result, the driving experience remains essentially unchanged, and as new communication devices emerge and information flow increases, the current setup struggles to cope. This project, building on the ambitions of Norwegian car company Think, set out to explore how communication technology could move the electric vehicle to the forefront of city mobility. By developing the idea of the 'connected car', seamless digital interaction between driver and vehicle can be enabled and, in turn, connect to lifestyle and aspiration.

The study investigated the potential of the vehicle to become a mobile information interface, offering services that go beyond social networking and route planning, to enable seamless digital connectivity between the car, home, workplace, family or friends in the city.

Central to this was exploring the true needs of urban driving and looking at how sustainable mobility offered by electric cars could lead to more inclusive mobility solutions for everyone. Fifteen people between the ages of 24 and 82 were interviewed and observed going about their daily routines. The project probed the extremes, from car-phobics to those utterly dependent on their vehicles. An interactive persona sheet was created for each individual, giving a snapshot of their lifestyle and needs, in which the car adapts to serve the drivers and passengers of tomorrow – across the spread of ages, functional abilities and personal preferences. A flexible interior provides opportunities for customisation: older people can access larger, higher-contrast cockpit dials, whilst those living in small city apartments can achieve more privacy, using the vehicle as an extension of the home.

There is better, more-secure storage within the vehicle for everyone. A digitally connected parked car might switch on to provide street lighting for passers by, act as a Wi-Fi hotspot, advertise local shops, or even point a lost tourist in the right direction. It might also be preheated and defrosted from your home.

A digitally connected car on the road might communicate with other vehicles, letting other people know its location and estimated time of arrival. To reduce visual clutter, the interface adapts to different situations and drivers, displaying information only when required.

3 The service

The transportation industry will have to adapt and change to these challenges in order to respond to such rapid social and technological change and the new matrix of challenges and opportunities that results. The automotive industry will inexorably change as patterns of car ownership change and as more vehicles are restricted or even banished from town and city centres. These will be increasingly pedestrianised to ease congestion, improve security and provide a better quality of life for all those who work, live and pursue leisure activities there.

If the transport and car industry has a long-term future beyond focusing on emerging markets, it will have to move from building and selling cars (or other single-purpose vehicles) for the open road to an emphasis on probing more deeply into the lifestyles, needs and aspirations of different groups of transport users, creating solutions between public and private transport.

The industry will need to move beyond its current conservative boundaries and engage in a dialogue with transport service providers, city planners, legislators and other stakeholders in the future of city transport. We are already experiencing the multimodal journey. This will merge and integrate more and more, to evolve heightened mobility within mass movement, in a socially responsible and sustainable nexus that recognises personal need and public facility.

New and emerging industries will move into the journey space, to provide transportation solutions as product and service merge. We already have new providers: Google's autonomous car, Tesla's electric car and (as yet at the conceptual stage only) 'supertube' intercity transport proposals – offering challenges to the existing providers and demonstrating innovation in product and use. Connected technology will allow crowd-sourced funding to support the development of new vehicles and systems.

We are on the cusp of an innovation of major significance, with autonomous vehicles on the horizon. The benefits are enormous: a desire for safety, a dislike of traffic congestion and a love of convenience will naturally drive this forward, giving impetus for the technology to overcome the challenges of navigation; and integration and payment are already in place.

Will this deliver innovation in design, packaging and engineering, or will these vehicles turn out to be existing cars with a new ability? What will these vehicles look like, and how will they function?

Autonomous vehicle design comes with a history. In the 1950s, General Motors (GM) used the Motorama exhibitions to display futuristic space-rocket-styled vehicles that would transform into driverless cars and platoon to form road trains on the highway. This was the logical conclusion of Norman Bel Geddes' vision for a future city connected by superhighways. The family car would become an extension of the home, with parents and children using the thus-liberated space for study, work and play.

Now Google has unveiled the Google car. This vehicle is far removed from the image of a bright technological future that the earlier GM concepts displayed. Gone are the references to new technology, speed of progress and the rocket age. The Google car is designed without any of these references or appeal. Aesthetically the vehicle is closer to a mobile domestic appliance, its design language subservient to its function, and the form and materials chosen outside the cultural norms for personal transport or private cars.

What are the opportunities for this type of vehicle and what sort of position in the hierarchy of transport will it hold?

The most obvious use of these vehicles is in a controlled environment as part of a larger system, making them ideal for the urban environment. There are clear advantages: you do not need a trained driver to operate the vehicle, and users with disability or visual impairment can use one, as can the elderly who may be experiencing a reduction in motor function. The vehicle can be a component within a system that would prevent or reduce accidents. It can operate in changing conditions as it will be able to communicate up-to-date data. Such vehicles will ‘talk’ to each other and adjust their routes accordingly.

We can imagine large parts of the city closed to conventional cars, with solely pedestrian zones. Here the function of the vehicle would be to move people from place to place within the city centre and to link tourist and leisure attractions with public transport. The vehicle would be used for short journeys, typically lasting less than 20 minutes, and at relatively slow speeds.

Such schemes are soon to be trialled in Milton Keynes as part of the LUTZ (Low-carbon Urban Transport Zone) programme. You can order the cab or pod electronically and be told when it will arrive. Short trips do not require the same level of passenger comfort as longer ones, so the vehicle exploits every inch of its tiny footprint, simply offering space for two passengers and luggage. The exterior is designed to look strong, stable and dignified, with large window areas. The interior has two seats and a navigation screen – and, of course, there is no steering wheel.

Case study 2: Mobilicity PPT (personalised public transport): Capoco Design / Merih Kunur / RCA Vehicle Design / HHCD

Image source: Merih Kunur

The Mobilicity Personalised Public Transport urban transport system has been developed to match the needs for mobility that will predominate in the large cities of tomorrow. The whole basis of the PPT approach is that the coming decades will require radically new methods of transport within these urban areas. It is vital that the three greatest problems of congestion, energy use and emissions (both local and global) are addressed in an innovative manner. It is a driverless, or automated, system based on a vehicle five metres long that has up to 12 seats, including one wheelchair space. It will offer flexible routes and timing, and operate under a demand-driven service model. The operation is cashless, with the ordering of vehicles and charging for trips both taking place via mobile phone.

The drivetrain is always a series hybrid with a lithium-ion battery pack, but offers a choice of power generation designed to be future-proof: biofuel internal-combustion engine, hydrogen internal-combustion engine or hydrogen fuel cell. The system will use 50% of the energy of a normal transit system and the operating costs will also be 50% lower, as a result of to the avoidance of the dominant driver labour costs. When compared to a car-based system, Mobilicity uses but a tiny fraction of the energy and road space of current solutions. The guidance system uses magnetic markers, backed up by GPS and direct distance measurement. The longitudinal control includes radar controls for obstacle detection and speed control.

The design challenges many current automotive trends. It has been designed for low-speed and low-power operation to actually match city street conditions. It has adopted small tyres and wheels to minimise machine space and maximise passenger space. These small tyres can optimally carry the required loads, and the consequent reduction in brake size is suitable for both the speed of operation and the fact that the kinetic energy is pumped back into the battery to be reused, rather than lost to the atmosphere.

Image source: Merih Kunur

4 The system

Urban mobility will require a greater range of transport solutions than we see presently, and they will have to be delivered through a more integrated transport policy, that blurs traditional boundaries between public and private services and vehicles. Providers will have to consider comprehensive solutions that will include vehicle, infrastructure and enabling technology if they are to be successful.

We will see changing patterns of ownership, including hire, smartcards and joint ownership or car-sharing schemes. We will see intelligent and driverless vehicles, the emergence of new service opportunities and providers, and the resultant shift in emphasis from products and personal ownership towards integrated services and pay-as-you-go travel.

Connected technology could provide a circular system for the design, development, public engagement, funding, manufacture and delivery of new solutions for successful urban transport.

There is a diversity of vehicle types making up urban transport. The widespread use of the private car has a significant impact on the environment and the quality of life of urban dwellers.

Cities have attempted to address these problems by planning pedestrian-only areas, imposing parking fees and introducing schemes such as road charging, along with the creation of congestion-free zones to reduce use of the car and cut air pollution and greenhouse gases. They have encouraged sustainable public transport and the use of walking and cycling to promote health and well-being.

Case study 3: Sentiment mapping for transport planning: TSB / Commonplace / RCA Vehicle Design

Image source: Song Wei Teo

Smart cities need smart citizens in order to be effective. 'Sentiment mapping' is about how to improve journeys in the future. The way you get from A to B often involves different methods of transport: walking, or taking the bus, train, or bicycle. This project explores how to make all those different modes of transport more connected using emerging technologies such as GPS, satellites, mobile phones and open data to improve transport systems.

Using social media and custom apps, vital subjective and objective information can be acquired from travellers, leading to real-time visualisations of where problems occur and how they are perceived. The idea is to give travellers a greater voice and control over their experience, to allow transport providers the opportunity to be more responsive and to build stronger connections between the two. Sentiment mapping lets transport providers know what travellers think, and makes them more responsive by empowering citizens to have a more effective voice in the way cities develop around them to meet their needs.

Image source: Farhana Safa

Case study 4: The 'DMax process' – the new black cab: Dale Harrow / Rama Gheerawo / Karsan / RCA Vehicle Design / HHCD

The traditional role of the vehicle designer has been to realise a concept for either the exterior or interior of a vehicle using form, colour, and material, with cultural or historic reference, often to enhance a brand.

This is a highly complex role, but now designers need to embrace a different way of working to realise solutions appropriate to the complexities of the contemporary urban environment. This includes a broader understanding of the issues, new processes and, fundamentally, working as part of a multidisciplinary team. Design is often regarded as the final stage of developing a solution, but in today's world design needs to be involved throughout the commercial process - to engage, provoke and illustrate solutions alongside other specialisms.

It is unusual to have a clean sheet of paper when designing the next generation of an icon of London such as the Black Cab. Although the current black cab is one of the few purpose-built taxis in the world, its design is now two decades old and in need of modernisation so that it can utilise the latest technology, to ensure it is fit for purpose in the 21st century, and meets Transport for London's (TfL's) mobility strategy. The new vehicle uses lightweight construction to reduce emissions and will be able to be specified with a variety of power plants, including hybrid and full electric.

The design study looked at how a newly designed taxi could meet the requirements of a new London fleet, while addressing the needs of passengers of all ages and abilities through an inclusive design approach. The taxi is a fundamental part of the landscape of urban transport within the city, providing a mode of transport that sits between a public and private vehicle.

Working with industry partners Studio Hexagon and vehicle company Karsan based in Turkey, the RCA's brief was to conduct research and create a new design that satisfied the requirements for both low emissions and regulations associated with the London taxi, while meeting the aspirations of drivers and passengers of all ages and abilities. The RCA's Vehicle Design programme and the Helen Hamlyn Centre jointly led the project for HHCD's Age & Ability Research Lab.

In redesigning the taxi, a process of research, co-design and evaluation has been developed which could become a model in the design of public transport. The design process was devised to encourage input throughout and to seek fundamental solutions. It was important from the outset to engage with Londoners, seek their views and understand their needs. We engaged with drivers, users and stakeholders such as TfL, and with operators and owners through workshops, consultation and via social media. This communication continued throughout the design process, and we constantly checked our findings with test rigs, illustrations, models and animations.

This process moves beyond traditional design methodology, in which a solution is first developed and then deployed. It takes the design process into new territories, beyond the immediate limitations of product development, enabling designers to consider fundamentals such as basic layout and construction methods, how the vehicle will be part of a bigger system and how it relates to public and place.

For the project, a hybrid process was developed using inclusive design methodology coupled to a vehicle design approach. Each of the design phases involved a series of iterative loops involving literature review, exploration, brainstorming, and user research and idea generation. The ideas that emerged from the workshops, interviews and user research were organised into five design challenges that were than developed further, using models, test rigs and animations.

We call this DMax – a 360-degree design and research process.

5 Conclusion

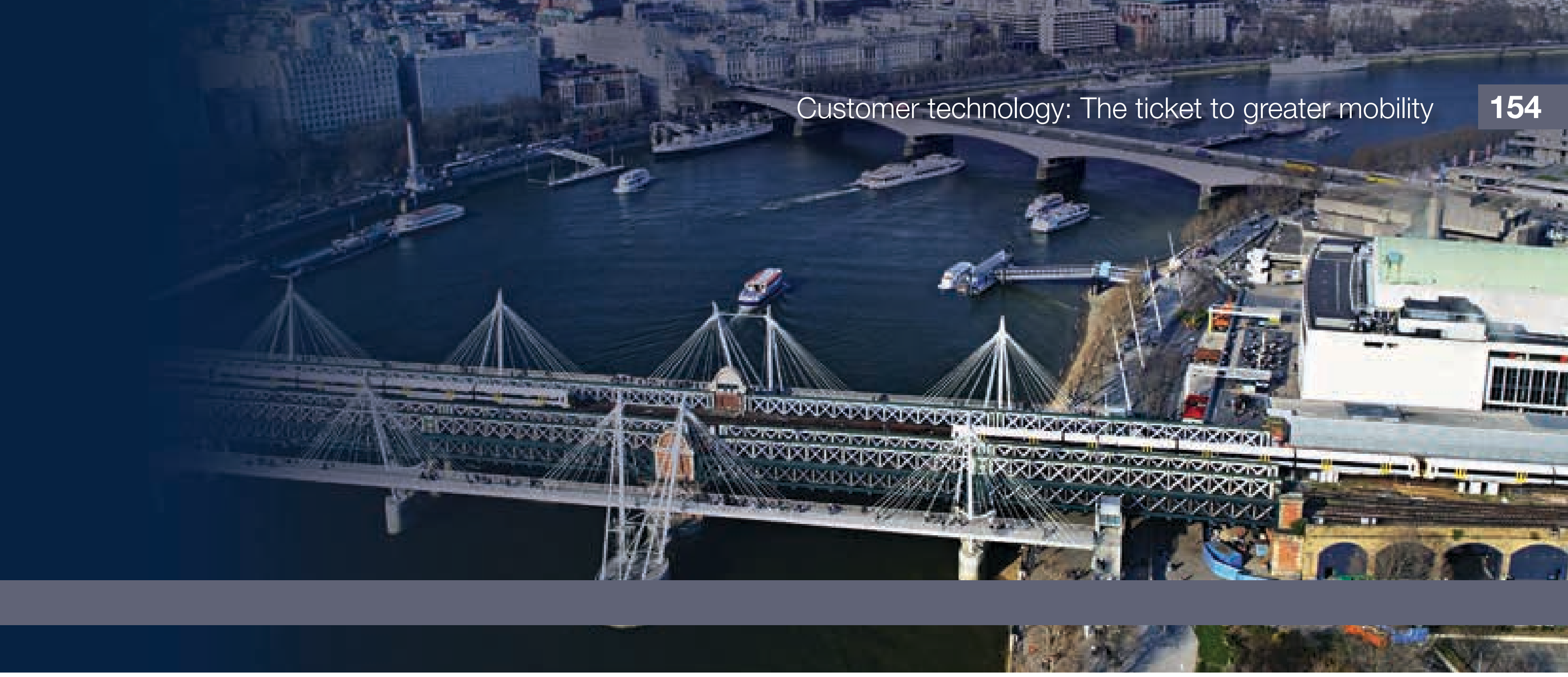
Digital connectivity is changing society, how we design and how our products and services will be manufactured and delivered. We need to devise new methods that are robust and appropriate for the task. If we can develop and adopt new practices, smart mobility in a smart city will enable the goal of seamless and sustainable travel to be realised.

9. Customer technology: The ticket to greater mobility

– by Shashi Verma, TfL

1 Introduction

The year 2008 marked a milestone in urbanisation: it was the first year in human history in which the majority of the world's population was living in cities. This is just a continuation of a long-term trend, over centuries, of people moving from small settlements to larger ones. Cities exist and grow for a simple reason – they allow economic interactions to take place more efficiently.



The ever-tighter clustering of people into cities is driven by the ever-changing nature of economic activity, which in modern life often requires face-to-face interaction at close quarters. Such behaviour is in complete contrast to the leading economic activity of the past, agriculture, which required space more than proximity.

The challenges for mobility arise just as much from the nature of economic activity as they do from the shape and size of cities. Fast-growing service industries, for example, create very different demands from, say, manufacturing, which leads to endless reshaping of the transport needs of London and many other cities. The combination of growth with the resulting demand for increased transport services produce a serious challenge for the sustainability of cities.

My own experience of transport stems from the cities in which I have lived or worked. My early life was spent in a small city, Ranchi, in India, where transport was barely a concern – it had plenty of roads for the size of its population. Ranchi is now choking – the population has tripled without any significant capacity having been added to road space or public transport.

Since then, I have had a chance to observe the bigger cities in India – New Delhi, Mumbai and Hyderabad; in the USA – Boston (where I spent four years) and the San Francisco Bay area; and also in South Africa. Watching London grow and prosper over the past 15 years, most of them spent actively taking part in its growth, has been fascinating, not least because I have been truly impressed by London's ability to continuously reinvent itself.

2 The case for cities

Much of my early experience in Transport for London (TfL) was while working on Crossrail. I was set a simple challenge: the Mayor wanted Crossrail, and I had to figure out a way to make it happen. It was patently obvious to the radical management brought in by Ken Livingstone that investment on the scale of Crossrail was not going to be obtained simply by arguing the traditional case based on cost–benefit analysis. Asking for £10 billion or more on the basis of time savings to London commuters (a pampered bunch in some narratives) from a Chancellor whose interests lay in building schools and hospitals was not a recipe for success.

The narrative that was built for why Crossrail was needed, and why and how it should be funded, remains the best example of a compelling, coherent argument for the need to address the challenge of urban mobility. So a brief summary of the case for Crossrail seems to me a good place to start.

London is a growing city. It has been growing for 200 years or more (apart from some minor disruption during the 1960s and 1970s when government policy forced employment out to the Home Counties). Not only is London growing, but there is also significant value to this growth: average productivity in inner London is two and a half times the average for the rest of the UK. Research by, among others, Professor Tony Venables of Oxford University, established that the effect of this productivity was not fully accounted for in cost–benefit analysis. In particular, the externality of increasing the productivity of an entire urban cluster (in this case London) by another employee joining the cluster, was missed.

But then, urban clusters are more productive partly because people are more productive when they work together. Research conducted by Professor Dan Graham of Imperial College London established levels of resulting productivity improvement in various industries. Service industries, in particular, benefit significantly from clustering tightly, with some businesses capable of a productivity increase of 20% simply by doubling the size of the cluster.

We were able to show that the primary constraint to increased clustering in London – a decade ago, at any rate – was the availability of transport. Perhaps, in a similar analysis today, the answer would have to be housing. (Even back then, housing was recognised as a constraint, but one that could be relieved if we were able to build the transport that was needed to link housing to areas of employment.) In all this debate it was recognised that the case for clustering – agglomeration benefits – made Crossrail a truly desirable investment. The benefits of the investment would be enhanced productivity and therefore GDP, and this was something that appealed to the Chancellor just as much as schools and hospitals did.

To my mind, the story of Crossrail redefines the role of mobility in terms of productivity, and it shows that some forms of transport are useful simply in order to support the economy. For the rest of this article I will not dwell on major new infrastructure – while it will always be an exciting and inevitable factor in the quest to support higher productivity, it has a tendency to overshadow the vital role of enhancing the infrastructure that is already in place.

With Crossrail, we had always intended to do everything possible to make the best use of London’s existing network. To do this, we investigated the ways in which people used the infrastructure, and the means by which we could optimise these. The case for gathering the investment needed for Crossrail was made on the basis that mobility enhances productivity. But it did not stop there. We also then followed it up with the way in which the funding was put together. If there is an enhancement to productivity, then there is a question about where these gains can be captured in the economy. We argued that the value of land in particular, and also businesses, gathers some of these benefits, with others going into an enhancement of wages.

With wages, taxation provides a mechanism for value capture, providing a cogent rationale for the government to invest in transport. With land, unfortunately, taxation does not provide the same sort of mechanism. Land taxation in the UK, as in most countries, is only obliquely related to value, and is often subject to various restrictions, rendering it almost useless as a method of value capture.

The solution therefore was to put a supplement on business rates, applicable on the imputed rental value of commercial property. Exemptions for small businesses (in practice for small properties) meant that nearly 87% of properties were exempt from the supplement, while reducing the value of the supplement by only 23%, a clear example of the 80:20 rule. All of this was supplemented by the expected surplus fares to be earned by the project over and above its operating costs.

Crossrail’s funding model has the potential for broader application. This was a £15 billion project that was struggling to get any political backing except from the Mayor of London and, of course, it was only one of many things that London’s business community wanted. The eventual funding model had only a third of the required sum coming from government, with another third coming from London’s business community, and the final third coming from the farebox. That was the basis on which the project won political support, and is the basis on which the project remains unassailable. The equation of a pound of public money winning three pounds of investment is just too good to be overlooked. If only other investment proposals could come up with a case and a funding package as compelling.

3 The role of technology – an example

Since handing my work on Crossrail over to others I have been running London's fare collection system, manifested most prominently in the Oyster card. This infrastructure is just as essential to the mobility of the city as the trains and signals that carry people around. The Oyster card system was launched in 2003, and since then has become the primary means for customers to pay their fares. Since launch, 80 million cards have been issued – ten times the population of London. About 98% of ticketing journeys on buses and 82% on the Tube are now made using an Oyster card, as are most National Rail journeys that are taken entirely within London.

So why is the fare collection system so central to the mobility story, and what might it say about other technology deployed in transport? The answer requires a glance backwards into the past.

Collecting fares has been a challenge since the dawn of transport. In the early years of horse-drawn buses, revenue collection was a rather simple affair. As you got on a bus, the conductor would tell you the fare to your destination. You paid in cash, and that was the end of it. The shortcoming of this system was that in the absence of a means to account for the money, a large part of it went missing. By some accounts two thirds of all revenue disappeared into the wrong hands – a clear example of a principal-agent problem[1] if ever there was one.

Throughout the nineteenth century, the viability of bus networks in London was compromised by employees pilfering the revenue. Of course, the operators of transport systems have to consider challenges like this every day, and the simple answer to this problem was the Bell Punch ticket, which had bus stops written down the centre of the ticket, with space on either side where the conductor would punch two holes: one to show where you got on and one to show how far you were allowed to go. Every now and then a revenue inspector would get on board, and if a passenger did not possess the appropriate ticket, penalties were issued to both the passenger and the conductor.

That simple innovation stopped the rampant theft of money from the bus network (not without many crippling strikes, it should be added). Dependence upon this system lasted a further 62 years before George Gibson, a London Transport employee, invented his wind-up ticket machine. The bus conductor entered the details of the required ticket using four adjustable knobs, and then wound a handle on the side of the machine to produce the ticket. Crucially, in light of the 1928 increase in maximum vehicle speed from 12 mph to 20 mph, it was operable with one hand so that the conductor could remain standing safely while dispensing tickets.

1 The problem of motivating one party (the agent) to act on behalf of another (the principal), arising when the incentives between the agent and the principal are not perfectly aligned and conflicts of interest arise; as a result, the agent may be tempted to act in his or her own interest rather the principal's, and conflicts of interest are almost inevitable.

Gibsons were superseded, briefly, by Clipper ticket machines before being replaced entirely by Oyster, of which more later. It is important to also consider the history of the mobility challenge issued by fare collection on rail. When the rail system began its commercial services in the 1830s, tickets were issued primarily on board the train. Services were slow enough and journeys long enough to make this feasible. Nevertheless, the need to reduce the number of physical tickets being issued led to a very early invention of season tickets. The creation of season tickets fulfilled another need too, one that is every bit as important to the mobility story – if people were to be persuaded to move away from London and live in the suburbs, promises about the cost of travel would have to be made. Consequently, this period also saw ten-year season tickets being issued, something we don't see any more.

When the Underground first opened with the Metropolitan Line in 1863, the business of selling tickets on the trains received its first serious challenge. Journeys were now short and system loads high. With the slam door design of rolling stock, ticket collectors could no longer move inside the carriages to sell tickets. The Underground, therefore, has never relied on revenue collection on board the trains, instead creating ticket booths at stations. Over time these evolved into the booking halls that we have today.

The Underground adopted season tickets, which were already popular on the railway, fulfilling a critical need for the commuter market. But the Underground went much further than the journey to work: it was soon presented as the way to travel to such attractions as London Zoo and Kew Gardens, as well as the theatre, shops and the tea rooms of London. Ticketing became an effective means of promoting these leisure activities, with combined tickets being issued for the Underground with the activity itself. An army of clerks sat in a dimly lit office on Edgware Road, accounting for all this money and sending it on to the respective attraction.

The big innovation on the Underground came in the early 1960s when the magnetic stripe ticket was invented and used for fare collection (a few years before there were any credit or debit cards, incidentally). This was a critical step in the development of modern automated fare collection, providing a new, versatile system in which tickets could be set at almost any value, including distance-based fares. Previous experiments, particularly in the USA, had led from coins that were accepted directly at the gate to metal tokens, the transition taking nearly half a century to implement – and it still meant that you could only buy or pay a single fare at a time.

Magnetic stripe ticketing was invented and reinvented again and again. The first generation of experimental technology gave way to a second in the late 1960s on the Victoria Line, but with fiddly equipment it didn't serve a sufficiently strong purpose. A reinvention in the 1980s brought the benefits of this technology to the entire Underground network, moving nearly all ticketing to the new system for the first time and getting rid of all older ticket types. The installation of gates across all central London stations around this time also meant that the magnetic stripe technology became essential for passengers to travel.

But no system stays still for long. The advantages gained by the magnetic stripe system were quickly absorbed by the growing traffic on the Tube in the 1980s. Within a few years, gates were being left open at peak times because they could not process people fast enough. Oyster addressed that simple need. Emerging radio frequency-enabled chips held more information than magnetic stripe cards and read it much faster. These smartcards have made it possible to more than double capacity at the gates. After much experimentation with the technology and being forced to go down the route of the Private Finance Initiative (PFI), London Regional Transport signed a contract to build a new ticketing system in 1998, and the Oyster system went live in 2003.

Public adoption of Oyster was slow at first, but passengers showed more interest when pay as you go (PAYG) and fare-capping were introduced. One of the biggest sources of frustration for customers had been having to choose whether to buy singles or a daily ticket at the start of each day. Capping removed the problem by providing the cheapest single fare and, if enough journeys were made, capping it to the daily 'Travelcard' fare.

In 2010, after many years of painful commercial negotiations and a lot of public pressure, Oyster PAYG was finally accepted on National Rail services in London as well. This also reintegrated fares that had been lost when Oyster was accepted on TfL services alone.

When it comes to developments in mobility, these changes to ticketing might seem trivial in comparison to grand infrastructure projects such as Crossrail. Oyster has been comparatively inexpensive, arrived with relatively little fanfare, and certainly wasn't accompanied by shiny new trains or stations. But investment in a simpler ticketing system is disproportionately productive. The total capital investment in Oyster on TfL services is still under £200 million. For that cost, there have been many benefits:

- At about 40 stations in London it has been possible to push back – or remove entirely – the need to expand the stations to accommodate wider gatelines. This capital investment would have needed at least £1 billion and possibly twice as much. Without either a better ticketing system or wider gatelines, revenue leakages alone would probably have cost even more.

- Reducing 'irregular' travel has saved about 2.5% of fares income on the Tube from being consumed by either fraud or being lost through the inability of the system to charge the right fares. That amounts to about £70 million per year.

- Overall, on the Tube and the buses, fares revenue has gone up by between 3% and 4%, worth between £100 million to £140 million. The analysis suggests that this is down to the convenience offered by a better fare collection system.

- Finally, replacing ticket sales on buses with Oyster PAYG means that buses don't spend as much time at bus stops while customers buy tickets when boarding. This reduction in waiting time means that fewer buses are needed to operate the same routes. The reduction in operating cost is estimated to be as much as 5%, or about £100 million per year.

All of that from just a £200 million investment. But it gets even better. The investment needed to extend Oyster to National Rail was much smaller, as most of the central services were already in place. A fragmented industry with a poor commercial set-up and competing objectives had been an obstruction to

Oyster going live on National Rail. When it was finally done – at TfL's expense – the total cost of the project was £33 million. Analysis by the Massachusetts Institute of Technology (MIT), and separately by consultants working for the Association of Train Operating Companies (ATOC), both concluded that the revenue uplift from Oyster was approximately 6%, or about £120 million per year. Try finding another transport investment with a business case half as good as that!

4 The future: How ticketing makes us more mobile

So what lessons can we learn from this history of fare collection? And how can we use what we know to improve mobility from here onwards?

The first lesson is that people travel to get somewhere – and, essentially, travel is just a means of getting there. While we in the world of transport think about transport all the time, the best journey for our customers is one that they experience as unobtrusive, comfortable and allowing space for them to get on with their lives, whether that be catching up on news, music, the latest crime novel or sleep. Anything that gets in the way of that is an intrusion.

Cars have evolved to give their users exactly this sort of experience. Gone are the days when you would walk around the car to make sure all the tyres were in shape and top up the radiator with water before setting off, doing battle with a heavy steering wheel. I have that experience from still occasionally driving my grandfather's 80-year-old car. But these days cars provide an experience that tries to mimic your living room – comfortable seats, air conditioning, entertainment, information, nifty holders for your drinks, and so on. And most importantly, cars have become less demanding of your attention. They don't break down as often. They don't need filling with water and the oil gauge checking. And, most importantly, they don't demand payment before you set off.

That is where the public transport experience still falls short. Despite the very visible progress that has been made in fare collection, led by London, our customers are reminded each time they travel that they have to go through the painful experience of exchanging the Bank of England's currency for ours before they can be allowed into the system. In effect, we, along with every other transport operator in the world, operate a separate currency zone: when you want to travel, you first visit the bureau de change.

At TfL, we realised that the next big step in supporting mobility would be to look at the fundamental process of fare collection, going back to the earliest days before the invention of tickets. The one thing to take away from more than a century's experience of ticketing is that the main purpose of a ticket is to provide proof of payment. All other attributes of a ticket are largely irrelevant in a mass-transit environment (even if they have further applications for long-distance trains or aviation, where there are discrete classes of travel and seat allocations). In mass transit, all that is sought is payment for a journey, usually charged solely on the basis of where and when a person enters and exits the system.

A significant trawl of technology options for fare collection, conducted in 2006 in collaboration with MIT, led us to consider contactless bank cards, which were then just beginning to be talked about. For the first time in the history of both the payments and transport industries, here was a solution that might finally make fare collection feel seamless.

Over the last eight years we have worked hard to turn this simple idea (albeit one that was complex to execute) into practice. We launched contactless bank cards on buses at the end of 2012, with a very limited proposition that was meant to appeal to only the 1% of journeys that were otherwise paid for by cash on the bus.

Despite the limited appeal, the take-up patterns of this new payment method tell us something about the adoption of innovation. Nearly a million individual contactless cards have been used to make journeys on buses – a million individuals who have felt comfortable fishing out their bank cards and paying for a transport journey. Most of these cards are seen only for a short period on buses before they vanish into the ether, evidence perhaps of tourists, who face the biggest mobility challenge in a new city and form the most tricky market segment for transport operators. And these cards have come from some 41 countries, again showing the improvement made in accessibility.

In 2014 a bigger launch of contactless payment technology on the Tube and rail systems took place, and results from that are still coming in. The Tube launch had to wait for a sophisticated back office to be built to take multiple individual touches and turn them into journeys, applying fares and capping. The development of this system in-house within TfL represents a different story – one of confidence in successful delivery of technology within the public sector, examples of which are few and far between.

As an aside, it also reflects one of the key benefits to London and UK of the 'TfL model', bringing infrastructure, services, technology and information together to deliver a clear purpose – an ability that other major British cities have not to date been granted by central government.

5 How technology aids mobility

A great city, a productive one, enables its citizens to manage their lives better. Since so much productivity is dependent on mobility, it is clear that the transport system's capacity has to support that. But the story only starts with capacity. All of our research shows that reliability scores very heavily in what customers want from a transport network.

In the UK, the investment in the rail network since the demise of Railtrack has helped make the system more reliable. Likewise, the investment made in London Underground, mainly since the unravelling of the ill-fated Public–Private Partnership (PPP), has made travelling in London more dependable, although much more work is needed on both over- and underground services. Some of the improvement so far has come from better track infrastructure, but in the case of the Underground it is the deployment of cutting-edge signalling technology that has both squeezed in more capacity and provided much higher reliability.

Other things have been just as influenced by technology, even if they don't contribute to physical infrastructure. Better information, available today through your mobile phone and various other channels, has improved the quality of the transport experience. Journey planning, once the preserve of face-to-face communication, then of a phone call, is now almost entirely digital. TfL's Journey Planner website has millions of hits every week, and the same is true of equivalent applications from transport agencies around the world. TfL's open data policy, whereby any transport information that can be made publicly available at reasonable cost is opened up freely and without restrictions, has brought about something of a revolution in the way that journey planning and real-time information is consumed. Any argument about the commercial value of this data is overwhelmed by the value derived by passengers in having more and better information available so that they can make choices as they wish.

But there is more, much more that remains to be done. The incipient improvements in technology for the management of road space promise a revolution that is probably bigger than anything seen in the recent past. The promise of automated vehicles and optimised traffic management is almost too great to be comprehensible. But at present, so is the hype surrounding these technologies.

If I go back to my original argument about the primary need for mobility, which is to allow density to lead to productivity, it is very difficult to see how road vehicles of any kind, automated or not, can attain to the efficiency with which rail transport is able to meet the needs of modern cities. Even automated vehicles will need road space, perhaps less of it but still more than rail, and they will need somewhere to park. I have heard some proponents of automated vehicles say that the occupants could be dropped off at work and the vehicle then return home to be parked there, until it is summoned when next needed. That one behaviour alone – generating two trips where one is needed – could more than negate the 5% to 50% increase in the efficiency of use of road space that might result from automation.

Quite how road space automation will progress remains to be seen. I am a firm believer that it is fundamentally a good idea, one whose time has come and one that will be unstoppable. What makes me remain cautious is that I have not yet seen or heard a compelling narrative about how this automation will improve cities. I am also somewhat pessimistic about the timescales over which these technologies will become mainstream. There is, it has to be said, far too much experience that suggests that the pace of implementation of these technologies is slower than its enthusiasts would want.

6 Conclusions

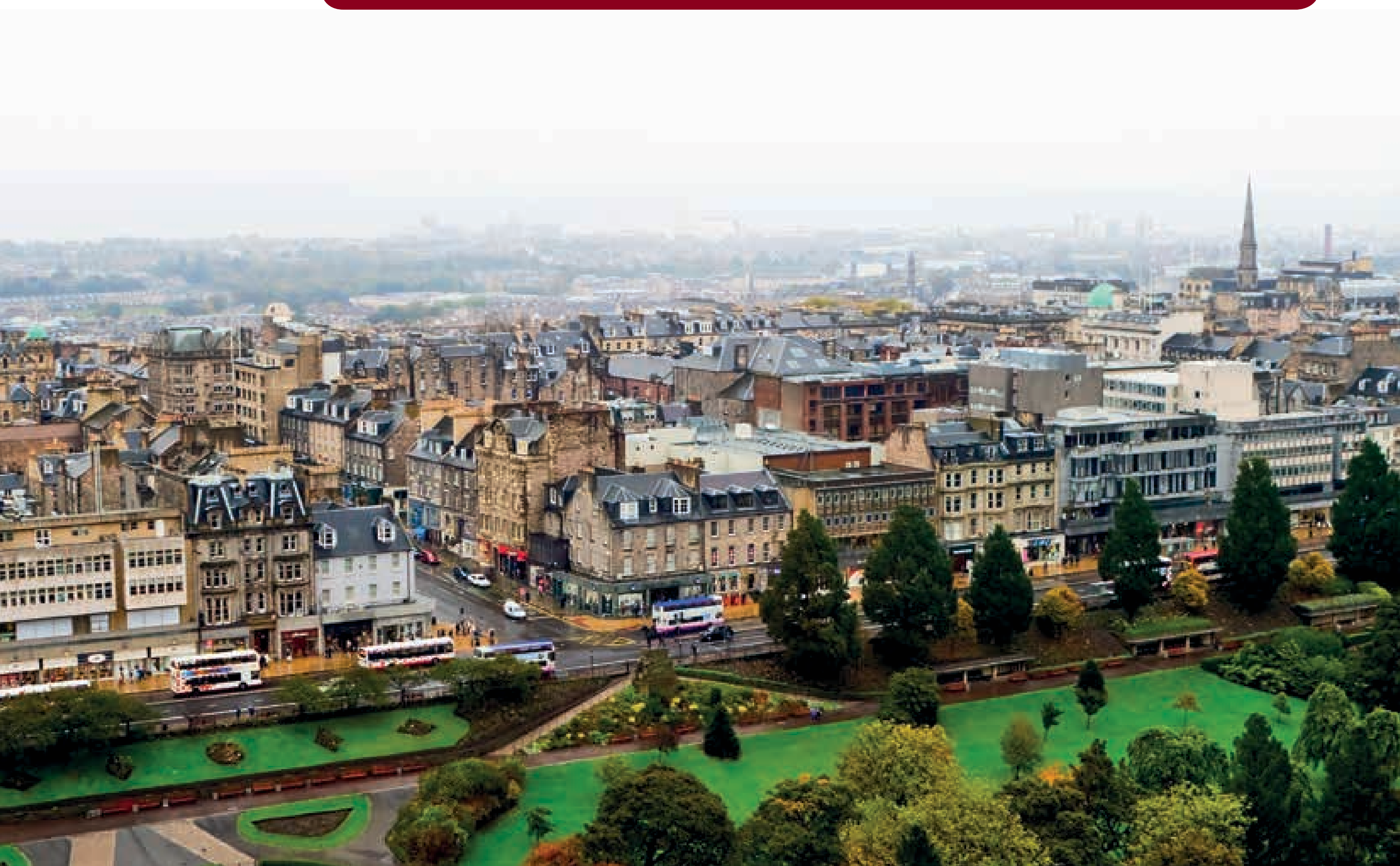
I end where I started. Productivity – the entire purpose of a city – is dependent on and defined by mobility. And increasingly, mobility will depend on technology in a way that we have not yet seen. I also look back on my past, reflecting upon the cities in the developing world that would benefit so much by exploring and exploiting the idea of mobility. The evidence, unfortunately, is not very promising on that front.

10. Urban space and street design

– by John Dales, Urban Movement

1 Where are we now?

In many respects it seems that, half a century after the publication of *Traffic in Towns* (aka the Buchanan Report), we're pretty much where we were in 1963. Which is to say that we're still struggling with the same questions and increasingly resorting to the same answers – even if they were often wrong last time.



The key questions remain those about how best to apportion urban street space and about the merits, or otherwise, of creating more space; and our answers still seem to arise from an unwillingness to manage urban mobility in ways that respond to the needs of our towns and cities as a whole. Instead – for obvious political, pragmatic and sometimes ideological reasons – we tend to conform transport policy to what we assume (and only sometimes know) individuals want. The report of the Traffic in Towns Steering Group summarised this conflict between the corporate and the individual with this vivid passage (Buchanan, 1963: 15):

> "We are nourishing at immense cost a monster of great potential destructiveness. And yet we love him dearly. Regarded in its collective aspect as 'the traffic problem', the motor car is clearly a menace which can spoil our civilisation. But translated into terms of our particular vehicle, it is one of our most treasured possessions or dearest ambitions, an immense convenience, an expander of the dimensions of life, an instrument of emancipation, a symbol of the modern age."

In the light of this assessment, the Steering Group waved a metaphorical white flag with the following admission (Buchanan & Crowther, 1963):

> "If we are to have any chance of living at peace with the motor car, we shall need a different sort of city."

Although we've spent decades trying to develop this "different sort of city", we have only achieved an unhappy compromise whereby we have streets that are unpleasant to be in and yet still unattractive to drive through. In his book *Straphanger: Saving our cities and ourselves from the automobile* (2012), the American author Taras Grescoe set out what he sees as the essential flaw in any policy of appeasement when it comes to private motor vehicles and cities (Grescoe, 2012: 12):

> "Even if a zero-emission miracle sedan, running on tap water and yielding only lavender-scented exhaust, appeared in dealerships tomorrow, it would not solve the fundamental problem with cars. The automobile was never an appropriate technology for the cities of America. As a form of mass transportation for the world, it is a disaster."

The UK Government's 'big idea' for dealing with the challenge of managing the demands for urban movement was set out as early as 1946 in *The Design and Layout of Roads in Built-Up Areas* (Ministry of War Transport, 1946), and repeated verbatim by that document's 1966 successor *Roads in Urban Areas* (Ministry of Transport et al., 1966). The idea was simple: "Traffic segregation… should be the keynote of modern road design." It arose from the notion that we came to call 'predict and provide', which said that cities should be designed so as to accommodate often abstract forecasts of motor traffic growth.

In 2014, we find that the rumours of the demise of 'predict and provide' have been exaggerated; and policymakers seem once again to have found themselves slaves of the latest growth predictions, rather than the masters of their own destiny that they could choose to be. This despite the fact that so many previous traffic growth forecasts came not to pass, and that the legacy of what we did under 'predict and provide' can hardly be said to have had a positive effect on urban space and street design.

So: when it comes to what we do with urban space, we're usually still working up from the fright induced by these forecasts, rather than back from rational decisions made about the character of the cities, towns and streets that we want. This is not least because we simply haven't made those decisions – through proper public debate – in the first place. For our urban areas to thrive in future, we need to ensure that the means serve the end, not the other way around.

If we were to work back from what's best for our cities, we'd find that 'traffic segregation' is just one tool in the box, and that places as complex as towns and cities, or indeed any given high street, demand a much more sophisticated approach to the management of movement than we generally seem willing to adopt.

Of course it's not all gloom, and a number of good ideas have infiltrated the processes of urban street design since the 1960s, 70s and 80s. One that is both promising and, I trust, likely to prove durable, is the idea that, when we come to decide what to do with any given street, we should consider not just its role in terms of movement – by all modes – but also its function as a place. Which is to say, we need to embrace the reasons that people may want to be in the street just as much as the reasons for which they may want to move through it.

London’s Roads Task Force (which should really be called the ‘Streets Task Force’) seems to be doing a good job of embedding within Transport for London (TfL) the idea that ‘road hierarchies’ based entirely on motor-traffic-carrying function are a thing of the past, to be replaced by a two-dimensional (movement-and-place) categorisation as one of nine members of the ‘Street Family’. I find it disappointing, though, that improving streets as places is portrayed as conditional on much of the motor traffic being put somewhere else – in ‘flyunders’ and maybe an Inner Orbital Tunnel – rather than forming part of a long-term strategy to reduce the amount of motor traffic we need to put anywhere.

Another positive component of where we are now is that cycling is increasingly (and rightly) understood as an ordinary (and benign) mode of transport, worthy of active promotion, not merely a pastime for children and sporty types. A focus on cycling-as-transport has, in turn, led to the understanding that, on streets where motor traffic volumes and speeds are high, physical separation of cycling from that traffic will be needed if more people are to be convinced that cycling is an attractive option for more of their journeys.

While this is an example of wise segregation, there is also still much interest in exploring the use of ‘shared space’, a concept that became popular in the UK during the early part of the century, although its definitions and manifestations cover a wide variety of street designs. Promoting both the efficient use of space and civility on the part of all users is at the heart of the idea, and while there is no doubt that this can be the right approach in the right circumstances, some user groups are generally uncomfortable with the idea.

Allied to 'shared space' is the idea of 'naked streets'. Focusing more specifically on decluttering – the removal of as much traffic management paraphernalia as possible, including signs, lines, poles and all other non-essential street furniture – this has gained very wide traction as a means of humanising most city streets.

New communications technologies have the potential to further reduce the amount of kit that needs to be placed in the street, but although there has generally been an increase in the appreciation of good wayfinding information, most of the best recent initiatives in this regard still rely on physical infrastructure, especially map-type signs.

The use of other new technologies – most notably in the form of congestion charging and the gradually widening range of 'eco-friendly' vehicles – has started to have a more obvious physical effect on the street, but they are as yet far from widespread.

Closing this section by returning to the 'bad news', there has been much talk since the turn of the century concerning 'the death of the High Street'. The finger is often pointed at the rise of internet shopping, and also the legacy of planning decisions that allowed retail and other attractions increasingly to locate away from population centres, in places that are easy to get to by car and easy to park at. Too little attention has been paid to the legacy of the physical changes we made to the high streets themselves – from over-simplistic forms of pedestrianisation at one end of the scale, to over-provision for motor traffic at the other. In a variety of ways, and often with the best of intentions, we simply made many of our streets and other urban spaces less pleasant places to be in.

While turning that tide should be the focus of future efforts, we currently stand – for a wide range of social, economic, environmental and cultural reasons – at a point where some of the measures most vigorously pursued by national and local government alike are more likely to harm the patient than heal. The most pernicious and specious is the popular notion that 'the saviour of the High Street' is more, more convenient, cheaper, and less-controlled car parking. But this is just one aspect of our continuing inability to do what our urban streets and spaces (indeed our towns and cities as a whole) need so much: to understand them better and embrace, rather than wish away, their complexity.

To summarise, the positive progress on our urban streets that was made during the 1990s and 2000s, and the potential of new approaches and technologies to build on that base, is in danger of being undermined by our willingness to take a path that Einstein advised strongly against when he said "We cannot solve problems by using the same kind of thinking we used when we created them".

2 What are the key challenges for the future?

There is a wide range of challenges that we face in seeking to build, nurture or strengthen our national urban street life. The biggest of these, of course, are the most important ones: if we cannot surmount them, we will only be able to make a difference at the margins. While I am struggling to find any big challenges that are new, the fact that we've been trying for a while does not, of course, mean that we should give up. Further, since these big challenges are the important ones – the linchpins, if you like – turning to face others risks would be of limited practical value.

At the top of my list comes the need for an effective, joined-up urban policy – one that covers both land-use and transport planning and is properly informed by an open, and as necessary ongoing, public discourse about what we want our towns and cities to be like. When people are asked about the attributes of the streets they like, they answer with words such as "clean", "safe", "attractive", "green" and "plenty to do"; not "easy to drive through", "cheap to park in" or even "laid out in beautiful Yorkstone". The challenge for urban policy is to start with a truly comprehensive and robust vision, instead of cutting straight to topic-based technical fixes for problems that haven't been properly established. It must also cover the short, medium and long terms.

It goes without saying, I trust, that we still need to pursue the objective of delivering new development (and changing older parts of town) in ways that genuinely and positively influence how people travel, through the location of attractions, activities and services in reasonable proximity to one another. While 2012's *National Planning Policy Framework* weakened planning authorities' powers to insist upon such development, it still left enough hooks on which to hang local policy to enable that policy to be robustly defended at inquiry, if necessary. One might also anticipate that the current desperation to build (almost anything, almost anywhere) will wane as the economic recovery becomes more assured. When it does, the opportunity will arise to reflect properly upon past failures and establish a firmer foundation for future action.

Related to this is the challenge of getting our minds around the need for robust mode-shift strategies, with clear actions assigned, not merely the same tired old mode-shift targets, associated with vague modal hierarchies that, as Hamlet would put it, are "More honour'd in the breach than the observance".

Another key challenge is to provide the support necessary to enable some of the major changes to current practice that are needed if a vision of more people-friendly streets is to escape the printed page and become reality. Foremost amongst such changes concern what may be termed 'non-personal traffic' (vehicles that serve us but are not owned or otherwise controlled by us) and/or 'non-discretionary traffic' (the type of traffic which persists despite disincentives – such as the Congestion Charge – which reduce the use of private motor vehicles).

Freight vehicles are a prime example; and when I see a poster proclaiming that the driver of a large articulated lorry cannot see all twelve of the cyclists in the vehicle's blind spot, I see a poster of a lorry that is not fit for purpose for use on urban streets. However, the changes in freight and construction practice that would be needed to get such vehicles off our streets (e.g. consolidation/distribution centres, limited times of access to certain streets, controls on vehicle size and emissions) all have significant cost implications that will fall largely on the customers or the public purse.

Taxis and private hire minicabs (which are exempt from London's Congestion Charge) are another example. As with freight, this industry is plainly commercially viable in its current form, but that is not a criterion that necessarily justifies the presence of such traffic on sensitive streets. Cabs of all types generally use space far less efficiently than buses (and indeed than walking or cycling), and in many streets and spaces can constitute the clear majority of the vehicle flow. If we want to reduce the number of these vehicles, at least in certain locations, it will be neither reasonable (nor politically acceptable) simply to ban them.

Related to the above is the challenge of enabling ordinary people to engage effectively with our less tangible transport demands. We have shown some ability to get our heads around the notion of 'sustainable travel' in so far as it relates to the journeys we take personally, but we blithely overlook its application to all the urban transport that we require for our lifestyles – from refuse collection to deliveries to the shop we use; from the 'white vans' used by the plumber we hire to the trucks used by the people who drop our parcels off, or deliver our furniture. We will need to have a firmer grasp of these matters if we are not to cry foul when our goods and services are more difficult to get hold of, or cost more than we've become used to. Here we see the need for effective public discourse emphasised: we need to know that this kind of 'pain' is worth it for the 'gain' we have previously identified, in terms of streets that are safe, clean, green…

A different type of challenge is that of transition. We may be happy with the vision, but unwilling to accept the process of getting there. The experience of Sheffield while it built its tram system (the Supertram) in the early 1990s is reminder of the scale of this challenge. Delivering mass cycling is another illustration of the point. If we had a cycle mode share of 10% or higher, we'd have a concomitant fall in the number of motor vehicles (of all sorts) on our streets. But to build such a high mode share will take years and will often depend on taking scarce street space from the modes (and the people) who use it now. The expectation of long-term benefit will often struggle as a justification for the certainty of short-/medium-term disruption to current travel patterns.

It would be remiss of me to close this section without referring to the basic challenge that will always face us in making decisions related to urban street and space design: the old chestnut of how best to use the space in any given centre or street, and how to implement decisions 'today' in ways that are sufficiently flexible to permit the layouts to respond to our requirements 'tomorrow'. A consistent thread through any such changes, though, should be the creation and maintenance of conditions that make both walking and cycling both be, and seem to be, safe and inviting.

3 What are the possible solutions to the identified challenges?

Continuing the theme of focusing on the highest-level challenges first, I consider that each town, city or region should (be required to) prepare a Movement Management Plan (MMP) – a statutory document that establishes a detailed, yet flexible, incremental strategy for changing patterns of personal travel and the transport of goods over the short, medium and long terms. A MMP will embrace different scenarios for economic growth, land use changes, and demographic change, and establish a wide range of connected actions – from policy, through planning controls, to infrastructure – designed to achieve targets for both mode share and trip-lengths. These targets will be neither arbitrary nor fixed, but will have a dynamic relationship with the capacity and other characteristics of the different modal networks to accommodate the number and type of trips predicted. So, for example, targets of a higher mode share for cycling on certain routes would need to be associated with specific proposals to make cycling more attractive on the streets in question; and should also influence the character of new development in the local area. In short, MMPs will be designed to make change happen.

Without a Plan of this type, I believe we will continue to do little more than hope for the best; publishing documents that are long on the right words but short on the necessary deeds; and taking action largely in response to events, rather than acting so as to influence them. Each MMP could, and probably should, be part of a broader urban development plan, such as the recently published draft *London Infrastructure Plan 2050: A consultation* (Greater London Authority, 2014). I trust that this Plan, the first of its kind in the UK to my knowledge, will help to establish a template (as an approach, not just a document) for all our urban areas.

In the late 1990s, the then Liverpool Architecture and Design Trust launched its Liverpool Design Guide initiative by asking the question: "Why are the cities we are building so different from the cities we like?" The central purpose of the type of MMP and/or urban development plan that I'm talking about is to change (or indeed maintain) towns and cities according to the answers that they themselves (i.e. their permanent and diurnal populations) give to the question: "What kind of town/city do we want?" For this reason, urban authorities – through elected mayors, for example – should engage in open public discourse about urban life to guide action. This does not have to be complex, and should focus on high-level outcomes, not problem-solving. The purpose is for the authorities to be able to say, in effect: "This is what you want your city to be like. Here are ways we can achieve that for you."

There's no avoiding the fact that appropriate budgets must also be part of the solution. However, this is not necessarily a matter of finding more cash and splashing it: it's a matter of spending what we have more thoughtfully and effectively. Although *Transforming England's Strategic Road Network* was launched by the Department of Transport in February 2014 (DfT, 2014a), with the promise of a "locked-in funding commitment" of £24 billion (DfT, 2014b), the same Department's October 2014 draft *Cycling Delivery Plan* (DfT, 2014c) contained no funding commitment for the comparatively small sums needed to create better walking and cycling infrastructure. Such imbalances are the motivation behind moves (promoted by the Campaign to Protect Rural England (CPRE), Sustrans, Living Streets and others) (CPRE, 2014) for a binding Cycling & Walking Investment Strategy to be added as an amendment to the Infrastructure Bill currently before Parliament (Infrastructure Bill, 2014–15).

More generally, existing budgets should be focused on meaningful outcomes, rather than on essentially arbitrary outputs (e.g. "cycling flows will be doubled" rather than "100 km of cycle lanes will be constructed").

Another highly beneficial move – and this would be an integral consideration of any MMP – would be more directly to associate capital and revenue spending. Maintenance is so clearly an essential role for any street or space that it seems almost perverse that expenditure and activity on keeping physical assets in good condition is so commonly divorced from the process of building those assets in the first place.

Turning to the challenge of major change in industries such as freight distribution, construction and taxis/minicabs, I see no other practical option but for the public sector to provide financial and, as necessary, regulatory support for the infrastructure and systems needed to transform the impact that they have on city streets, and to manage the change that will inevitably come from new vehicle and communication technologies in any case. Simple bans are not the way: we need to know, for example, how a system of breaking loads for delivery to urban centres by small, low-emission vehicles at specific times of day will work in practice; what the implications for infrastructure and systems will be; what the costs will be; and how they should be borne.

It is most likely to be in the relatively closed systems represented by these industries, it seems to me, that the much-hyped advent of autonomous vehicles will have greatest value – at least in the first decades of their use. A fleet of automated distribution/collection vehicles, covering designated areas, using an established street network, travelling to and from a specific depot, and coordinated by a town-centre management company or Business Improvement District, is not too hard (for me, at least) to envisage. Similarly, it is not hard to foresee that small driverless cars could become a form of free-range personal rapid transit (PRT) that will combine the current benefits of taxis, minicabs and car clubs and replace them all. As these would be electrically powered, largely on-call (using apps or similar), and locally garaged in space-efficient mechanical parking towers or shafts, the need for on-street ranking and circulating for trade would be minimised – with obvious benefits for street life. Managing the transition will, however, be a task every bit as difficult as achieving the necessary technological advances. The implied loss of jobs and of ‘the Knowledge’ culture are bound to meet resistance, of varying degrees of rationality.

Turning to buses, a London-like system of service planning, provision and control is plainly essential in all towns and cities. Deregulation may have suited a political and economic ideology, but it has proved largely disastrous when it comes to enabling citizens to travel as efficiently as their towns and cities need them to.

As for general traffic, I am one of many professionals who believe that more numerous, more extensive, more intelligent and more fair congestion charging programmes are the only rational means of apportioning urban street space in ways that meet the city's wider needs rather than individual wants. It is the latter, of course, that currently constrain politicians' thinking; but, again, a properly informed MMP will provide a firm basis for progress.

Just as politically contentious are the matters of control and enforcement concerning how people drive and park. The lifelong 'right to drive' that we assume we have been granted when we pass our test must be challenged, and there is excellent road safety data to support change, starting with graduated driver licensing. Similarly, the 'right to park', beloved by some politicians as a contemporary form of bread and circuses, can and should be conformed to the facts that plainly show how much more important modes other than the car are for our local high-street economies.

And speaking of other modes, at the risk of stating the blindingly obvious, we need to assert the practical (not merely notional) supremacy of walking and cycling on streets where people live, work and otherwise spend their time. We're too used to treating these modes like water ("they'll get through somehow, however small the gaps"), but we should increasingly use simple, easy-to-use-and-understand tools to ensure that we're providing the space that will make people feel welcome to come on foot and on bikes. TfL's approach to modelling 'Pedestrian Comfort Level' (PCL) is a good place to start.

New information and communications technologies will make possible the development of simple, flexible, 'smart' ticketing/payment across all modes in the form of 'CityCards', including bus, train, cab/car club (driverless or otherwise), bike hire, car parking, and river bus. These will represent a true step forward in the seamlessness of urban transit which, allied to radical improvements in wayfinding technology, will transform the ease with which people are able to move around town in ways that are increasingly harmonious with our aspiration to have urban streets and spaces that are pleasant places to be in.

If I seem to have said very little about street design itself, that is intentional. The principles of good urban design are essentially timeless, 'handed down' by a rational assessment of why we like the places we like – 2000's *By Design* by the then Department of the Environment, Transport and the Regions covers this ground, if you wish to explore it. What we most need to be able to deliver on these principles are not great advances in design technique, but rather the removal of the constraints imposed by an approach to providing for urban movement that fails to see the wood for the trees.

4 What are the policy recommendations?

Not least for want of space, it's time for me to become less discursive. The following is my take on appropriate policies likely to help achieve the types of change described above.

- Urban authorities should conduct (and periodically refresh) a simple, open dialogue with their citizens about what they consider to be the most necessary and desirable qualities of the towns and cities they inhabit.

- The 'vision' established by this dialogue should be used to guide the preparation of a statutory MMP (or broader urban development plan) to guide specific actions to achieve specific ends over the short, medium and long terms. Such MMPs should be subject to an annual review (with progress report), and a comprehensive review every five years.

- National and local planning policy should be configured so as to enable the development industry to create increasingly compact, mixed towns and cities. Corporate profit is essential for development to proceed, but a more level playing field, established by planning controls (determined according to the MMP and/or urban development plan), will ensure that profit levels are conformed to the needs of the place hosting the development.

- Associated with the above, transport planning policy needs to establish more meaningful hierarchies to guide intervention. Simple modal priorities have been too easy to ignore in practice, and a more sophisticated appreciation of each street is in any case required. Combined movement-and-place categorisations should be adopted, with appropriate parameters for transport and character assigned to each. 'Place' should be valued on local terms, not according to a single, citywide scale.

- We need to replace an unhelpful (and somewhat arbitrary) planning focus on greenbelt/ brownfield designations with more meaningful transport/ land-use planning criteria. These could include public transport quality and/or new measures of average journey distance(s) for key-indicator trip purposes (e.g. home to work, to school, to shops).

- Policy should be crafted to enable the principle of 'localism' to properly influence the planning of key public-sector trip attractors such as education and health facilities. Overall city efficiency should not be sacrificed to (current thinking on) relatively narrow 'business' efficiency in the health and education sectors. More generally, the specious notion of 'widening choice' should not be used to underpin policies that actively encourage citizens to travel more, or further, than they would wish – and than the city needs.

- At the national level, we need enhanced 'traffic justice', which is to say a policy and legal framework that establishes driving as a privilege and responsibility, not a right, with the concomitant enhancement of protection for more vulnerable users of our streets.

- Associated with the above, national policy should seek to actively raise driving standards through (initially) graduated driver licensing and (ultimately) compulsory driver retesting every ten years.

- Urban public transport services should be re-regulated on the London model.

- Urban authorities should establish and maintain a policy (and mechanism) of single-platform, multimodal transport payment regimes.

- Street design guidance should be flexible, showing examples of how to implement an agreed range of principles in different types of environment, while ensuring appropriate provision for 'protected groups' established by the Equality Act 2010. The existing basket of related national guidance, containing documents produced to address relatively narrow concerns, should be overhauled and rationalised to both encourage and enable street layouts to be coherent and inclusive; not the Frankenstein's monster of a jumbled kit-of-parts that we are too familiar with today.

5 What are the areas for further research?

To inform, support and guide both policy and action to transform the quality of our urban street life, in some or all its many facets, I think that research to answer the following questions would be especially helpful.

- What have cities in other countries done to limit, or otherwise control, the number of large (freight and construction) vehicles that are allowed access to central area streets? What policy, legal and practical instruments were used? What problems were encountered in implementation? How has the success (or otherwise) of any such initiatives or programmes been gauged?

- Which towns and cities have sought to adopt detailed mode share targets, backed by specific policies and implementation plans? What were the results? What are the barriers, if any, to adopting comparable approaches across the whole of the UK?

- What measurable economic, social and environmental impacts have initiatives to encourage more walking and cycling had in specific high streets and urban centres (in the UK or elsewhere)? What other evidence is there (e.g. before/after surveys of public satisfaction or business confidence) that points to the benefits of making walking and cycling safer and easier?

- Similarly, what evidence is there concerning the measurable impacts on specific high streets or urban centres of increasing the amount of parking, reducing its price, or other parking management changes?

- How can measures such as Transport for London's 'Valuing Urban Realm' Toolkit best be developed so as to produce reliable and credible monetary values for the user benefits, and the wider economic, health and social benefits, associated with a better public realm?

- What street design features are of real value to ordinary people with a range of mobility impairments? What do such people make of existing features, whether these have been designed by the book or otherwise, intended to assist their mobility? What features are essential, which merely desirable, and which actually irrelevant or actively unhelpful for different user groups?

- Related to the above, what technological developments will aid people with different mobility impairments to use streets safely and conveniently without conventional physical interventions in the streetscape?

- How can smartphone and smartcard technologies help people make travel decisions that are best for both themselves and the city (e.g. helping people walk rather than queue for short taxi trips; route-finding for trips using bike hire/share systems; guidance on the most rapid and/or cheapest public transport options)?

- What effect, if any, would statutory driver retesting (say) every ten years have on the quality of our driving, and what effect would any improvement in the quality of our driving have on road safety? What would the economic, social and political implications of introducing such a policy be? Is there any relevant evidence from other countries?

- What opportunities do advances in vehicle technology (including full autonomy) offer in terms of making better use of urban street space, particularly by releasing space currently occupied by vehicles – both moving and stationary – for other users and uses?

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11. Spontaneous mobility

– by John Miles, Cambridge University

Urban mobility in the UK presents a challenge of enormous proportions. By observation, the transport infrastructures in our conurbations and urban areas are already on the point of overload and, if nothing changes in the way in which we move about within our urban spaces, the population growth which is forecast between now and 2050 can result only in even worse congestion and pollution. Continued economic growth and public well-being would be compromised in such circumstances.

This essay addresses the challenge of urban transportation and introduces the concept of 'spontaneous mobility' as a means of resolving the 'car versus city' dilemma.

1 The nature of the problem

Congestion in our urban spaces is rife. Traffic moves continuously throughout the day, with peaks of intensity in the morning and the late afternoon, and may be thought of as comprising two major components – tidal flows and Brownian motion.

Tidal flows are evidenced by logjams in our city centres and queues of traffic in our suburbs at times when people want to travel to work – or to any other place where the start time of their event is fixed (such as school runs, trips to football matches and concerts, etc.). They are characterised as 'tidal' because the traffic moves strongly in one direction first and then moves equally strongly in the reverse direction some time later.

In addition to the tidal flows, there is a different type of almost random activity in which travellers go from one place to another without there being any fixed and regular formula with which to describe the overall patterns of movement. This type of flow might be characterised as 'Brownian motion', a series of random events in which traffic moves from one place to another with no discernible overall pattern.

The problem of urban mobility arises because there is simply not enough road space in most cities to cope with the intensity of both types of flow, which are additive during peak-hour travel periods. For private travellers, the travel mode of choice is usually the car and, unless the car is full (which it frequently is not), the road space occupied by the vehicle is quite inefficiently used. Clearly, either we need to provide more road space (as was attempted in the Fifties and Sixties with the introduction of elevated roads and urban motorways), or we must provide a means of transport which uses the available road space more efficiently. High-capacity public transport systems such as trams, underground railways and urban light rail have seen a resurgence of popularity in recent years. Many emerging cities have built vast new underground railway systems as the centrepiece of their expansion plans (Moscow, Shanghai and São Paolo are good examples) and a number of UK cities (such as Manchester, Sheffield and Nottingham) have re-introduced trams. But these solutions are expensive and require significant alteration to our urban landscape – a change that is very difficult to manage, not only because of the enormous cost but also because of the disruption which inevitably accompanies any serious urban infrastructure project, not to mention the social dislocation which follows from the compulsory purchase and demolition of homes and places of business.

The question “What is affordable to the local population?” is intriguing. Facilities which place a burden on the taxpayer (for example, building an urban underground railway) are universally unwelcome and are frequently deemed to be ‘unaffordable’. However, those which are funded by the traveller at the traveller’s choice (for example, a car) encounter no such resistance – even if they represent a bigger demand on the traveller’s annual budget in the form of loan repayments, fuel purchases, road tax, insurance costs, and maintenance costs. The great advantages of the car lie in the fact that users will willingly pay for it. Such is the power of personal choice.

So, we are faced with a dilemma: we want to move more freely and to exercise personal choice, but we cannot find enough road space in which to achieve that objective, nor enough money with which to build the ubiquitous mass-transit systems which would render the car unnecessary. This, then, is our ‘car versus city’ dilemma defined.

2 Big Brother versus Wikipedia

It has become fashionable to demonise the car as the cause of urban congestion. The argument states that the car is an evil which must be curbed – or, better still, removed. In the vigorous pursuit of this line, the protagonists become blind to the social liberation which personal motorised transport has brought to modern society, and ignore the thriving economic activity which has followed from that social revolution. Forcing people out of their cars has become a major policy objective, and many planning authorities now impose parking restrictions on any new building developments, on the questionable premise that if homes and places of business have no parking facilities, people won’t continue to own cars. The objective may be admirable, but the solution is resented. Rather than trying to force people to conform to a new paradigm for transport by imposing rules and regulations on them, can we find another way?

The information age has brought with it many interesting developments in social engagement. In the past, if local or central government wanted to coerce the public into any particular course of action, their only real option was to develop policies and impose rules from above. Such rules may have been created with the best of intentions, but they were seldom appreciated. No one likes the approach of 'Big Brother'. But in the information age, a new model has emerged – that of free-will engagement in the pursuit of personal benefit. This is a very powerful formula, and demonstrably produces avalanche effects. No one relishes an ID card, but everyone carries a credit card and a mobile phone – the two devices which give away just about everything that is personal about our lives: where we are at any given time, and what we spending our money on. Likewise, subscribers regularly divulge personal information in exchange for access to a variety of apps on their mobile phones, or the membership of privilege clubs such as store cards. Consumers regularly trade something precious (privacy, in these cases) for personal advantage; is it not likely, then, that the same consumers will also trade something precious (the use of their car) for advantage? What, then, would succeed in tempting a traveller away from using the car for any given urban journey?

3 Convenience versus price

The answer is probably some combination of convenience and price advantage. Greater convenience is a huge influencer of choice for people who are busy, and money is the critical limiter of everything. If we are to trump the perceived advantages of the car, we must provide travel solutions that are more convenient, and at the same time no more expensive, than taking the car. Ideally, the solutions will also be less carbon intensive.

There are many reasons why people own cars – it is recognised amongst marketing professionals that the decision to purchase a car is one of the most complex and non-logic-driven choices made by consumers at the point of sale. Fortunately, our goal is not to prevent people from *owning* cars. Rather, it is to reduce their *frequency of use* once purchased. The critical challenge is therefore to understand why people choose to use them for everyday urban journeys, even though traffic congestion renders this an unpleasant experience.

There are several advantages to using the car, and in most cases the balance of these advantages outweighs the disadvantages of sitting in a traffic queue (otherwise there would be far fewer cars on the road during rush hour!). The major perceived advantages are:

- **Spontaneous availability** – the traveller can go whenever he or she pleases, without reference to any third party, and without the constraint of adhering to someone else's timetable.

- **End-to-end transport** – the traveller can move conveniently from door to door without unacceptable additional movements.

- **Personal space –** the traveller can make the journey in private, alone, or with friends or family.

- **Price –** this probably means the cost of fuel, because car owners usually only allow for the marginal cost of using their cars.

It would be very difficult to satisfy all of these demands simultaneously with any single-mode system other than the car (which, of course, is why the car has so clearly flourished at the expense of the other modes). However, in the age of intelligent systems, there is an increasing possibility that some competitive alternative could be created using a multimodal approach, particularly if some new advantages could be traded against the disadvantages of using the car, principal amongst which are:

- **Lost time –** sitting in traffic queues and searching for parking spaces is time consuming, but the attention of the driver is nevertheless required at all times. In terms of productive working or personal fulfilment, it is 'lost time'.

- **Frustration –** sitting in queues and looking for somewhere to park is also frustrating, and leads to incidents of anger and 'road rage'.

- **Added cost –** this is mainly the cost of parking, which, in some rail station and city-centre areas can cost many times as much as the fuel consumed on the journey.

The scene is now set: can we provide a public transport system which matches the advantages of the car and offers benefits in those areas where the car is perceived to have disadvantages?

4 Vertically Integrated Public Transport Systems (VIP Transport Systems)

The ideal public transport system needs to deal with both the tidal flow type of demand and the Brownian motion variety too. It also needs to provide a service which matches the two big plus points of the car: spontaneous mobility and door-to-door service. And, recognising that it cannot offer personal space, it needs to compensate by providing advantages where the car has disadvantages. It should offer lost-time recovery and reduced stress, at a price which is less than the price of fuel plus parking charges for the journeys in question.

Lost-time recovery is a major potential advantage of public transport. Since the traveller is not required to be in charge of the vehicle, time spent travelling can – given the right immediate environment–be used to read or work. The provision of comfortable seats, Wi-Fi connections, and space/power for laptops and other devices opens the opportunity for previously lost time in travelling to be recovered and used for work or leisure purposes.

Clearly, no single form of public transport could span the spectrum of needs described above. But a collection of different transport modes, interconnected by a public information system which is easily accessible by the travelling public, could come close.

4.1 Mass-transit systems

Without doubt, the most attractive forms of public transport for heavy tidal flows are the mass-transit solutions such as underground railways, trams, and light-rail systems. Bus rapid transit systems may also be included in this category. However, at an average cost in the UK of some £30m per mile for surface rail-guided systems (and underground systems are far more expensive), there are limits to the coverage that such systems can provide. Even a ten-mile stretch of modern tramway would cost in the region of £300m by the time it had been commissioned, and this would provide only one single spine route across a city. Multiple lines providing more comprehensive coverage would quickly run towards £1 billion per system. This is clearly unaffordable for most cities, and we therefore need to restrict our thinking to more ‘entry-level’ tram systems.

The problem with the entry-level system is that it cannot provide a close and convenient point of connection for most inbound city travellers. As a consequence, the traveller needs to take their car to the tram station and, once in the car, the temptation is to make the entire journey in it to the city centre because parking at the tram station and changing modes of transport is seen to be inconvenient (and also costly if there is a car-parking fee). Another disadvantage of the entry-level tram system is that it clearly cannot deal with the demands of Brownian motion.

4.2 Strategic bus services

Traditional buses are a much cheaper form of mass-transit system and, arguably, could be used to provide the linking services between most travellers' homes and the nearest point of connection to the tram. Running to a fixed timetable and along certain fixed routes, buses can provide strategic transport services at an affordable price. Recent experiments with high-quality services (e.g. Arriva's Sapphire service and Stagecoach's Gold service) that provide new buses with redesigned interiors and public Wi-Fi are beginning to make a positive impact. But to achieve worthwhile economics of operation, and a suitably small carbon footprint per passenger journey, depends on achieving relatively high load factors on the working routes throughout the day, which means that there are only limited routes on which such services can thrive. These are typically strategic routes which are aligned with regular passenger flows running through high-density residential/commercial zones.

For the remaining demands for urban mobility in low-density neighbourhoods (which, collectively, represent a large number of journeys in any city), too many buses running empty during off-peak hours destroy the business and environmental cases for providing comprehensive bus services. As a result, off-peak services get cut, and buses become unattractive for members of the public who live some distance from the strategic bus routes, or in the low-density suburbs. Travellers of this type must suffer the inconvenience of using a suboptimal service, or else revert to using the car.

4.3 Tactical bus services ('Bus-to-Go')

An ideal solution in the low-density suburbs, or for the Brownian motion traveller, would be an 'on-demand' bus. This is a bus which comes when called, and collects the traveller from the point of call. It is similar to a private-hire (taxi) service but it has two major advantages which arise because it provides shared space in a medium-sized vehicle. First, one single vehicle replaces seven to eight vehicles on the road (cars that would previously have been used by the passengers), assuming that the capacity of the bus is around 14 to 16 seats and the vehicle runs approximately half full for most of the time. Second, the price and the carbon footprint per passenger are much lower than for a taxi, because the running costs and emissions are shared by all the passengers.

This is not a new idea – 'Dial-a-Bus' services have been introduced in many UK cities from the early 1970s on, and there are some services which are still in operation today. But they have never been an economic success and, where they survive, they are usually subsidised. Moreover, they often fall far short of providing the ideal 'spontaneous' response to demand. (There are some examples currently in operation which require the passenger to book 24 hours in advance!) But a truly on-demand system, picking up within a guaranteed time of being called, and dropping the passenger at the required destination at no later than a guaranteed arrival time, would be a very attractive offering. The question is – could it really be delivered?

Under closer examination, the concept of Dial-a-Bus remains sound. The failure lies in the execution. The services provided to date have used telephone systems to make customer bookings, which are then allocated to vehicles by a human dispatcher (often) working with a paper-based system or two-way radio. In many cases, the system degenerates to drivers returning to base to collect the next journey schedule which lists all the passengers to be collected over the next duty roster. This mechanism is simply not agile enough to provide the on-demand service required by time-sensitive travellers and, as a result, the services fall out of favour and are used only by people who can afford to wait for their pickup and are indifferent to the time of arrival at their destination.

With the coming of the information age, however, all of this could change. The way forward is pointed by the private-hire companies, which already operate massive fleet services throughout most UK cities. Typically, there are 10 to 15 times more private-hire vehicles than buses running in UK cities – maybe around 2,000 vehicles for a medium-sized city. All of these vehicles are allocated spontaneously on receipt of the customer call, and most operators these days are in real-time contact with every vehicle on their fleet through an Internet connection and handheld device mounted on the vehicle dashboard. This allows the operator to track the movement of each vehicle, and to provide customers with real-time information about the vehicle identification and the pick-up time.

Bus-to-Go, at its simplest, is a shared taxi service which provides the spontaneity and flexibility of a private-hire service at the price of a bus. Work is already underway on software products that can reroute vehicles dynamically to collect new customers whilst the vehicle is already in service. This is an essential prerequisite of efficient and attractive shared services, because the optimal allocation of vehicles is a very complex mathematical task. It is essential to the economics of the operation that all vehicles have an average load factor in the order of at least 50%, so the vehicle must divert to collect additional passengers whenever possible. On the other hand, it is essential to the customers that vehicles arrive within a pre-agreed elapsed time (the guaranteed pick-up time) and deposit them at their destination before a pre-agreed end time (the guaranteed destination time). Matching these conflicting demands and continuously optimising vehicle/driver resources over a fleet of several thousand vehicles is something that can only be done by an automated system. But early studies suggest that such a system could be operated profitably, and the reduction of vehicles on the road (by a factor of anything up to the seven to eight suggested previously) would make a significant contribution to congestion relief.

4.4 Last-mile systems

The final piece of the VIP transport system jigsaw is the most futuristic. It recognises that our city centres must be vibrant and socially active places which attract people in large numbers for business, shopping and leisure purposes. Footfall is a key measure of success, and anything that makes travelling to the city centre unattractive reduces footfall. Congestion is one of the chief deterrents to visiting the city centre, and many UK cities are beginning to create pedestrianised zones within their central retail and commercial spaces. This makes for much more attractive city-centre spaces but, in some cases, these zones can be quite large and it makes providing public mobility within them much more difficult.

The advent of automation opens the door to a completely new form of transport which could be well suited to this application. Low-speed autonomous transport systems (L-SATS) are small, lightweight vehicles which are self-driving and can mingle safely with pedestrians in mixed-space environments. Moving at around 10–12 mph, these vehicles could provide short-range on-demand services to customers who wish to ‘hop’ across large pedestrianised zones whilst working or shopping. Early studies suggest that fleets of these vehicles could be operated in much the same way as private-hire services are currently operated, and that the services thus provided would be highly competitive and cost-effective.

Sharing space between pedestrians and vehicles may seem daunting, but it is a concept that has attracted a lot of attention amongst transport planners in recent years, and some interesting developments have taken place. An example is Exhibition Road in Kensington, London, where the pavement kerb and regular street furniture has been removed and a much more open space has been created. This new space is now shared by pedestrians and normal road-going vehicles which can travel at much more than the 10–12 mph proposed for the L-SATS. The evidence to date is that the two different types of user can coexist in the shared space quite safely.

4.5 An illustrative journey

The core purpose of a VIP transport system is to provide spontaneous end-to-end services for customers who wish to travel at will. Each element of such a service as described above will present a challenge to the future provider/operator, but the successful functioning of the overall system as an integrated whole is paramount. If the traveller loses access to any part of the system, the entire functionality is lost and the reaction will be to revert to the car. Access must therefore be instant and reliable for those who travel on demand – and the ubiquitous handheld device provides the key. Being able to hail the service and navigate the system is a process which has already been enabled by the information age; the evidence lies in the plethora of apps and services which is already available to anyone who has an interest in using them.

So it is not too much of a stretch of the imagination to consider James, a young professional who lives in the suburbs and rises early each working day to travel to work in the city centre, as a candidate for such a transport system. He used to take his car, and arrive in the city centre after a long, delay-prone journey to battle for an expensive parking space before arriving at the office and starting work. He would delay his departure after the day's work to avoid the evening traffic, and eventually arrive home exhausted at quite a late hour. He would never consider taking public transport because of the congestion, unpredictability, and inconvenience involved – and to come home early for a special occasion, or to relieve his partner of parenting duties, would be very nearly out of the question.

In our city of the future, James' hectic life is different. Rising in the morning and knowing what time he will be ready, he touches the handheld to make his reservation with the local Bus-to-Go provider. Fifteen minutes later, after a quick breakfast, the bus arrives for the pickup. On board, the vehicle is half full and there is a space for James to open his laptop and check emails. Once he is immersed in his laptop, the diversions to pick up other travellers are not a concern to him – he knows he will arrive at the tram station by the guaranteed latest time, so he is not particularly concerned that the journey there takes longer than it would in his car. He can work on the bus, and he doesn't have to mess around finding somewhere to park.

At the tram station, the transfer between transport modes is quick and easy. The trams are frequent and swift and, again, have Wi-Fi, so journey time is not wasted. On arrival at the city-centre tram stop, he is still around half a mile from his office, which is a pleasant walk in the sunshine but misery in the pouring rain. The app on his handheld has already hailed the L-SATS service (which works automatically for regular trips, learning from pervious journeys), and the L-SATS vehicle identification is communicated, allowing James to step from the tram and find his allocated vehicle very quickly. During the short journey, he makes a brief call home and then alights ready for work. The whole journey has been booked and billed automatically through his handheld without him having to pre-book or buy tickets. He may – or may not – make the reverse journey at his usual time; and he may – or may not – make the same journey tomorrow. There is no penalty in breaking regular travel patterns because there is no pre-booking. The system is spontaneous.

5 Conclusions

The vertically integrated public transport system of the future is very likely to be a multimodal offering connected by a universally accessible information system which handles booking, billing and any other customer transaction or information requirements. Between the various modal elements of the system, and the interconnecting information systems, spontaneous end-to-end services could be provided to a level which makes it preferable to taking the car. If this tipping point can be reached, there is every reason to be optimistic that the congestion which threatens to throttle the further development of our cities can be relieved and, indeed, even greater levels of public mobility can be provided without detriment to the existing urban infrastructure.

Rather than reconfiguring our cities to fit vast, fixed-route, public transport systems, we should be able to reconfigure our transport systems to fit our cities – a process which is altogether more attractive, and affordable. And all of this is conferred by a new era of system control technologies (the schedulers for the Bus-to-Go service, and the autonomous control systems for the low-speed autonomous transport systems) and the 'connection' which is already provided through our personal communications devices. The development of these new systems will be driven by the needs of customers, and shaped by their demands to make travel more convenient. There is an intensely Darwinian nature to the development of apps and services over the Internet, and the strapline of “Everything that is inconvenient will change” offers an insight into the future that is very optimistic in its outlook. Not everything can be delivered through free-market activity: the spine tram system, which is essential to James’ journey, can only be delivered by local authorities working with central government – but the peripheral systems which are necessary to make the tram successful can be delivered by private enterprise.

Giving the traveller something which is more attractive than taking the car is a much more powerful formula than beating the car user into submission.

12. Regulation: Bridge or barrier

– by Philip Pank

1 Executive summary

A seed was sown this summer, which if nurtured to fruition has the potential to transform the way people and goods get around our cities by 2050. Funding for road tests of driverless cars, and a review of the regulations and laws governing the use of autonomous vehicles, could mark the beginning of a journey to more efficient, pleasant, healthy and safe cities. Ministers believe that the technology has the potential to transform the cityscape, save thousands of lives, reduce emissions of greenhouse gases and pollution, improve journey times and increase mobility for both old and young. They spy a commercial opportunity in positioning Britain as a pole for cutting-edge industry.

This chapter explores the regulatory changes being considered and asks the question “Is regulation likely to be a bridge or barrier to change?” Its focus is on the potential for regulation to help – or hinder – driverless technology, which could then have a transformational impact on safety, air quality, haulage and the taxi trade.

A view of regulation as both enabler and inhibiter of change has emerged during interviews with key stakeholders. Government is applauded for taking baby steps towards the future, but criticised for failing to facilitate the transformational potential of technology.

Industry is driving change by investing in technologies with the potential to transform cities and the way we travel. Some players fear that the possible benefits will be held back by a timid response from politicians and regulators.

2 Regulation: Bridge or barrier?

From the corner of my eye, the passenger was just visible as he jumped out of a stationary car up ahead, and ran across the roadway in front of the world’s first driverless juggernaut. “Just visible” because although the author was nominally in control of the 40-tonne lorry, he had ceded use of steering, accelerator and brakes to a bank of PCs mounted behind the driver’s seat and, rather than trying to drive through the simulated urban traffic, was watching a movie on a tablet computer while simultaneously sending an email to a colleague. Who says drivers can’t multitask?

The cab lurched and stopped dead before hitting the family saloon, the 4×4 or the errant pedestrian. Warning lights flashed, an alarm sounded, and the engine cut out, not to restart until the ‘driver’ had given the all-clear. Still neither foot was in contact with accelerator or brake pedals, and there was no need to touch the steering wheel.

The radar, ultrasound, GPS-enabled sensors and cameras interpreted signals from the stop–start traffic, calibrated safe distance and speed, revived the engine… and the lorry resumed its journey.

The driver was both productive and able to enjoy some leisure time. Precise activation of accelerator, brakes and gear change were calculated to reduce fuel consumption by 18% in heavy traffic.

This was no sci-fi movie, but a trial of prototype technology developed by truck manufacturer Scania. From the company's test track, we set off in robotic convoy along the E4 Motorway south of Stockholm in a 120-tonne, 30-wheel 'platoon' of other prototype lorries, all communicating by Wi-Fi and radar, and controlled by computer. The three trucks seemed buffered by an invisible force field as their pedals worked in unison, reducing the distance between each to a minimum and so reducing wind resistance, fuel consumption and emissions – and the potential for human error.

That was last autumn. Now the UK authorities are playing catch-up as they seek to position Britain as a global hub for the research and development of autonomous vehicles (AVs). Lorry platoons are expected, along with trials in three cities of driverless cars.

As the car and lorry manufacturers investing millions in prototype vehicles lobby for change of national, regional and global motoring laws, officials at the Department for Transport (DfT) have spied an opportunity. Britain is one of two European countries not to have ratified the 1968 Vienna Convention on Road Traffic, which sets international driving standards and stipulates that drivers must be present and be able to control their vehicle. Signatories agreed to modify the convention in May, but DfT expects a two-year delay before the change is implemented, giving Britain a head start in the quest for AV technology.

In August, DfT launched a review of laws and regulations to allow testing on British streets, and the previous month, with the Department for Business, Innovation & Skills, offered £10 million towards the cost of trials in two or three cities. Vince Cable, the Business Secretary, proclaimed that from early 2015 fleets of driverless cars would be plying the streets of Britain.

Its review documents are openly enthusiastic. The technology “offers enormous opportunities in terms of safety on the roads, better management of road space to reduce congestion and potentially reducing emissions,” it said (DfT, 2014a). Road casualties, congestion, fuel bills and emissions could be cut, while road capacity could increase along with mobility for both the old and the young. Journey times could become more consistent, while at the same time the British automobile industry could benefit from a boom in uptake of modern cars, it claimed. The Government said (Innovate UK, 2014): “Driverless cars will improve people’s lives and the way they travel, improve the world’s towns and cities, create opportunities for the UK automotive sector and related industries, and have a large impact on the way towns are designed and engineered.”

Its review, due to be published by the end of the year, will consider regulations covering standards for vehicles and infrastructure, equipment that must be carried on cars, driver behaviour, road signs, and licensing of driver and car. It will consider guidance and legal requirements in the Highway Code, the Road Traffic Act 1988 and the Road Vehicles (Construction and Use) Regulations 1986; devolved powers in Scotland, Wales and Northern Ireland; EU Directives and Regulations governing licensing and vehicle construction; and the Vienna Convention.

It will consider whether special training is needed for drivers involved in testing AVs, and whether observers must accompany test drivers, who will continue to be banned from using handheld mobile phones, driving under the influence of alcohol and driving without a seatbelt.

Regulations will be imposed to ensure that AVs are roadworthy and may demand compulsory software updates or modular design to allow outdated components to be replaced. Eventually, government will have to decide how AVs should be taxed, and whether the fact that they are autonomous should feature in DVLA records. Issues of liability, insurance and data privacy will be key to any future regulation.

The government review is limited in scope to focus on tests of cars with ‘high automation’, where a full set of controls exist and a driver must be ready and able to assume control, rather than those with ‘full automation’, vehicles in which no human intervention is needed. DfT expects little change to existing rules on product liability, whereby manufacturers are liable in the case of crash or injury resulting from the malfunction of advanced braking systems, cruise control or other automated systems designed to make driving safer or easier. It is putting off detailed consideration of liability in the case of a crash involving a fully automated vehicle.

Vehicles will have to be insured in line with the Road Traffic Act, and insurers will be expected to offer suitable products. Manufacturers will be expected to place bonds against liabilities for third-party injury if insurers do not oblige. Data collection will have to comply with existing data protection laws. Black-box recorders may become compulsory in driverless cars, raising renewed debate on privacy.

Government will have to decide whether to amend laws and regulations piecemeal, or introduce standalone regulations.

At present there is no legal impediment to the testing of prototype AVs on the streets of Britain, so long as they are insured, proven to be roadworthy and safe to drive, have a full set of controls to allow a qualified driver to take over, and are limited to confined areas.

The next step in the regulatory journey is to allow their testing on public roads in a wide range of conditions, particularly in towns and cities. The testing of prototype technology is likely to be approved at the local level by next year. However, type approval of AVs, which would be needed before they can be sold to the public, is likely to be decided at the EU level, with it being many years before agreement is reached. Global vehicle standards set by the United Nations Economic Commission for Europe through its World Forum for Harmonization of Vehicle Regulations (WP.29) are also expected to take many years to change.

In the interim, the UK Government hopes that road tests will help identify issues which may or may not require regulation, and thus dictate the extent to which authorities regulate or deregulate.

The review is already a year later than planned, and critics allege that its lack of ambition will hold Britain back relative to some international peers.

“This paper does not seek to analyse the long-term outcome,” stated DfT (2014b). It has no plans to regulate for the use of fully autonomous vehicles, which proponents claim will unlock the full benefits of AV technology. They claim that while government regulation will be needed to kick-start the introduction of driverless technology, official inertia, laws and regulation will act to slow – or even block – the widespread use of AVs. Regulation will be a short-term bridge but a long-term barrier to the uptake of technology, they claim. There is a risk that this could stymie radical change and limit the future development of urban mobility.

There certainly appears to be official appetite for regulatory changes that may be needed to spur early experimentation with driverless technology. It remains unclear if policymakers would sanction the deep-seated change that may be needed to attain the full perceived benefits of technology; these could include road pricing, an eventual ban on traditional vehicles in city centres, and an overhaul of traffic laws and infrastructure – including the potential removal of traffic lights from city streets.

Paul Buchanan, a transport economist at Volterra Partners, suggested that the British Government has yet to fully understand the changes needed to allow for AVs to be introduced and go on to attain their full benefit. Civic authorities are by and large hesitant to become pioneers on the world stage, and would rather follow successful trials in other countries or city states. However, the technology is already arriving on British roads, driven by the investment of large amounts of private-sector capital.

“A major barrier to the full implementation of AVs is legislation and governance,” Mr Buchanan stated.

“There is the ‘who is responsible for a crash between two driverless cars?’ issue. Is it the car? Is it the software system that controls the roads? Is it the owner of that particular vehicle? I don’t know, but it can’t be beyond the wit of man to come up with a solution to that; but it is going to have to be pushed downwards by government rather than come in any other way. So there is a government decision there that is going to have to be taken hard.”

He suggested that laws banning traditional vehicles would have to be adopted to secure the potential gains offered by driverless technology.

“The second one is an equally difficult policy decision, I think, and it is how much of the benefits do you get during the gradual change over from manually driven to automatic – and at some point I have no doubt that an authority is going to have to say, ‘Right, no more cars that are driven by humans, not allowed on my streets.’ That could be the Highways Agency on motorways, or TfL [Transport for London] in London,” Mr Buchanan said.

“My guess is that the benefits are pretty low until you get to 90%-plus driverless. What will be more apparent is that human drivers are pretty rubbish compared with everyone else, and they are going to have to do it. Maybe it becomes Central London that is where you get the biggest gains from it, and you say ‘OK, only driverless cars within the Congestion Charge Zone’. There is going to have to be force there, otherwise you will get a lot of people who say ‘I like driving’, and who do not think about the external cost to other people.”

Some supporters of the technology say that the potential gains in road capacity that AVs could bring will be contingent on charging users for road space. Mr Buchanan said both that road pricing will be a necessary tool to encourage early adoption of AVs, and that it will in turn be required if the full benefits that the technology can bring are to be attained.

"It seems to combine the best elements of a car – the individual door-to-door transport – with a technology which makes it much more efficient. It bridges that gap between public and private transport. You get the shared taxi-style private-public transport. You can choose to share that journey with someone else and get rid of city-centre car parking, the dead space that it creates, and I think it has to be linked to charging. If you think of it as a taxi rather than your own car, it gets rid of a lot of that barrier about paying for road space, because we are used to paying for it in a taxi; you are not used to paying for it in your own car. If you can break that, I think it becomes the key to introducing road pricing," he said.

"If you think about the opposition to even paying for road use, to be told that you are not allowed to drive, a basic human right as it is perceived by many people, is going to be massively politically unpopular, at least at that moment.

"It just has to be driven by a bold politician. Someone has to say that the potential gains from this are huge, so we have to make the decision which is politically unpopular in the short term."

In a paper, *Autonomous vehicles – the next revolution* (Buchanan et al., 2013), Mr Buchanan and his colleagues considered a number of future scenarios in which driverless technology is introduced and comes to dominance in the decades to come. Under the timescale set out in the report, by 2025 vehicles will be parking themselves, communicating with each other, driving autonomously in traffic jams or on the highway, and bringing considerable disruption to the taxi trade.

Car ownership will decline and car sharing increase, collisions will be significantly reduced and disruption be wrought on the bus industry, with driverless vehicles on segregated or guided busways, by 2035.

In the decade to 2045, the size, weight and emissions of vehicles will decline, electric propulsion will become widespread, street parking will be reduced, lanes become narrower, and fiscal incentives (such as road charging and pay-as-you-go journeys) will become the norm.

From 2045 onwards, autonomous door-to-door travel will be commonplace, urban congestion will fall sharply and congestion on the highway will be eradicated, along with collisions; and cities will grow.

However, the vision assumes that technology continues to develop at pace "without prevention from potential issues such as legislation".

If and when regulations are redrawn, government is likely to promote the safety benefits of driverless cars. More than 90% of crashes are caused by human error, according to the World Road Association. More than one million people are killed every year on the roads around the world, and up to 50 million injured.

Mr Buchanan suggested that UK authorities would continue to follow the lead of other countries.

"Until it is obvious that we are well behind other countries, at which point there will be cries to catch up. I don't know that we have the ambition or nerve to lead it, and I guess we don't have a big domestic car manufacturer which might have changed the incentives," he said. "I think there is going to come a time when you are going to have to legislate. It is crucial."

John Miles, chair of the Intelligent Mobility Working Group at the UK Automotive Council, said that Britain was better placed than other European countries to reap the benefits of driverless cars because it had not ratified the Vienna Convention.

"It is something that is going to take several years to see through, but there is a very positive frame of mind from the DfT towards this stuff," he said.

"They could put more money towards it, but you could always argue that. If you look at the amount of money Google are spending on this and you look at the amount of money the American Government is putting to one side to assist with all this, the amount of money the British Government is putting into this is very small. It is commendable, but it is small. The Government is pretty alive to this, and some of the good guys in government are working their hardest to make money available."

He said that regulation, rather than deregulation, would be central to official attempts to encourage investment in the technology.

“I don’t see that they have any alternative but to regulate, because all vehicles are regulated. It is part of our societal expectation that there will be a degree of control on safety associated with anything which people have common contact with. I don’t think there is any question that the Government should take its hands off, but it should go to the loosest fit possible. The minimum amount of regulation is what they should be aiming for. They should restrict themselves to the achievement of outcomes, and the regulations should ensure that the achievement of outcomes is as safe as it can be.”

Mr Miles said that the Government was attempting to enable autonomous driving technology and was acting as a bridge to its implementation. However, there is a risk that too much regulation will hold industry back.

“You have to have regulation, and in that sense it will always be something of a barrier to any set of cowboys – and quite rightly so. On the other hand, I think that the attitude of the British Government at the moment is very much in bridge mode. It is trying to build the route to the future.

“The Government is trying to encourage industry down a path, and it is acting as a bridge, so I think it is both bridge and barrier in the right measure.”

By 2020 many cars on the roads will be semi-autonomous and have the ability to drive themselves. Crawl control, where the vehicle takes over in slow-moving traffic, adaptive cruise control, lane change, automatic parking, and satellite navigation systems will be commonplace.

“All of those capabilities are in our cars now, or are within a year or two [of being in them]. You only have to link them up and you have the technological capability for the car to drive itself on any journey. That is an astoundingly near-term prospect. The thing that will slow it down is first and foremost the rate of take-up. The other obvious thing that will hold it back is regulation, because we might couple all these things together within the next two years but we are not going to have a regulatory situation which allows you to have the car in driverless mode without any human control. That is not going to happen inside two years, but it might happen inside ten,” Mr Miles said.

“By 2040 just about every vehicle on the road will be capable of autonomous movement.”

Draconian laws to improve air quality could speed up the arrival of AVs, as car manufacturers promote the technology as a way of beating ever tighter emissions standards. “It is going to be more and more difficult for them to meet the lower and lower targets that are ratcheting in, so they will take all possible measures to achieve the targets that are being set – and if automatic control becomes one of those measures, then they will put a lot of weight behind that,” said Mr Miles. He rejected claims that road pricing would be necessary.

Professor David Begg predicted that AVs which are controlled remotely and have their location and time of travel logged would open the way for road pricing. He said that the adoption of airline-style pricing, where the cost of travel is greatest at the busiest times, “would transform journey time reliability, giving certainty of journey time which road users crave”. He predicted in a study, *A 2050 Vision for London: What are the implications of driverless transport?* (Begg, 2014), that in the 2020s and 2030s AVs were likely to be expensive novelties which would require a qualified driver to be present and ready to assume control. By the 2040s or 2050s, middle-income families would be able to afford fully automated vehicles which could transport non-drivers safely. The study predicted that a large number of motorists might still want to drive themselves, raising the prospect of complex rules and regulations to control traditional and fully automated vehicles plying the same streets.

Professor Begg nonetheless predicted that regulation would not thwart the arrival of driverless car technology. He said: “I don’t think that the technology will be held back. The question is: will you be able to use it, and will you be able to use it with your feet up, reading the newspaper? At what point will DfT allow the use of driverless vehicle technology without having to be alert and attentive? In all the trials in America, you still have to have a driver there to take over the steering.”

The US Institute of Electrical and Electronics Engineers predicted that 75% of vehicles would be autonomous by 2040.

Four US states and the District of Columbia have already approved tests of driverless cars. Google's prototype vehicle has driven more than 300,000 miles on Californian roads. Last year, Nissan conducted a test of an AV on the open road in Japan for the first time. Volvo, the Swedish car manufacturer, has won permission to test 100 driverless cars in the city of Gothenburg.

In addition to the potential for saving lives, proponents point to expected economic rewards for countries which adopt driverless cars. The Eno Center for Transportation predicted economic benefits in the United States of US$25 billion a year if just 10% of the fleet is AV. This would rise to US$450 billion a year at high penetration rates. A paper setting out policy recommendations for the uptake of driverless technology, authored by Eno Fellow Daniel Fagnant and his advisor at the University of Texas Kara Kockelman, warned that "the effects of excessive caution… may be harmful to technological advancement" (Fagnant & Kockelman, 2013). They urged a consistent framework for licensing AV vehicles, and standardised safety regulations across states. "Regardless of how safe AVs eventually become, there is likely to be an initial perception that they are potentially unsafe because of the lack of a human driver. Perception issues have often been known to drive policy and could delay implementation. Moreover, if AVs are held to a much higher standard that [sic] human drivers, which is likely given perception issues, AV costs will rise and fewer people will be able to purchase them," they said.

A paper for the RAND Corporation's Transportation, Space and Technology Program (Anderson et al., 2014) concluded that the Federal Government in the United States should consider making subsidies available to consumers or manufacturers, similar to the tax credits on offer to people who buy electric cars. Such a scheme would be a clear bridge to uptake, and the potential consequent transformation of urban mobility.

Yet some stakeholders remain wary, suggesting that predictions of the mass take-up of driverless technology are overoptimistic.

Edmund King, President of the AA, said: "This pilot from next year is only a pilot. It will probably only happen on a few roads. There is an element of hype around driverless cars. What we should possibly look at is how all these other elements (anti-lock brakes, lane assist, park assist, cruise control, crawl control) can improve mobility and make driving safer.

"I still think the more likely scenario will be the car that includes the main elements of a driverless car, which make the journey easier, safer, more regulated; but a majority of drivers still do not want to give up total control of the car."

A Populus poll for the AA found that 67% of drivers want to remain in control of their vehicle.

"They will be developed, and they will be on the roads, but I think that because of mobility issues and the desire for individual mobility by drivers, the driver will still be sitting in the car and the driver will still have his hands on the wheel or the mouse, whatever it is," said Mr King.

A similar view on the part of officials may have contributed to the limited scope of the British Government's review.

Mr King said that regulations were inadequate at present for the implementation of driverless vehicles. Road traffic laws and regulations, the Highway Code and speed limits were all based on a driver being present, he said. "I think it would need a sustained review, rather than just a few tweaks around the edges, otherwise you will get your loophole lawyers driving cart and horses through any inconsistencies or charges brought against drivers. I am not sure it is being thoroughly looked at."

3 Conclusions

British authorities are positioning the country to make maximum returns from a short-term window of opportunity opened by current regulation. There is no intention to consider the long-term transformation of mobility and cities which technology could bring. Policymakers and regulators have no interest in changing laws to make sure that the country is a global pioneer of change.

There is concern on the part of some stakeholders that this approach will needlessly hold Britain back, and condemn people living in cities to breathe filthy air and to contend with dangerous streets and worsening congestion. Others see the benefits of inertia. They say that technology is developing at such a rapid pace that to regulate quickly would create a legal framework which will become out of date just as quickly as it is written. Fiscal incentives are supported, but comprehensive regulation is at this stage being opposed. The current review is welcomed as a good start to facilitate the testing of driverless technology on British roads. More work is needed, however, to consider the long-term impact of regulation and the potential for change.

The consensus is clear: there is a need for continued regulation; regulation will be both a bridge, and a barrier, to change.

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13. The (likely) future of urban mobility

– by Timothy Papandreou, SFMTA

1 Introduction

Until recently, the last fifty years in transport saw no major revolution that has altered the whole scene – we have merely witnessed a few minor tweaks here and there. However, the past five years alone have seen more change and more disruption than the whole previous fifty combined. In fact, they have set the stage for transformation over the next ten on a scale never before seen since the mass production of the automobile. Fully one century later from that era we will be in a familiar and yet very different world. If the last five years of innovation and disruption alone are any indication of what lies ahead, we're in for a wild and bumpy ride leading to an upheaval of the status quo of transport services and choices.

On the basis of my interactions with dozens of cities and transport organisations, and hundreds of mobility services providers around the world, I have come to the conclusion that there are a few key trends that will shape the future of our transport in a way that will be exciting for many – and challenging for some. In this essay, I will attempt to synthesise a multitude of occurrences and forces that have been observed already, and those that are most likely to be seen in the future. Of course, events could take a different turn from the predictions I make here, but going by what I have witnessed, and drawing conclusions from talking to those with whom I interact, the writing is on the wall – so to speak – and the trends pretty compelling.

It's less of a matter of 'if' and more of a matter of 'when'. Moreover, some of the key disruptions have already started to shake the idea of what it means to travel, even touching our very own identity. We have a great opportunity in this next decade to finally get it right and shift the transport industry to a point where we would like to be – to move toward a more sustainable and more resilient society and civilisation.

2 Major trends in the recent past

Firstly, the seven major trends that over the past five to ten years have set the stage for the ten years to come can be categorised as follows:

- Demographic changes, with Baby Boomers and Millennials in large numbers
- Preferences for urban living and more flexible lifestyles
- Wi-Fi, GPS, sensors and smartphones
- Anywhere everywhere connectivity
- Car driving/ownership preference changes
- Travel as part of life experiences
- Redefining transport through new street designs, service providers and systems

3 Demographic changes, with Baby Boomers and Millennials in large numbers

The last decade has seen many aspects of demographics turned on their head. Most significant is the recent dramatic shift of the two polar ends of the demographic pyramid, which is now beginning to look more like an hourglass. Two generations, the ones that are retiring from work (the Baby Boomers) and the ones that are just entering the workforce (the Millennials), are in numbers never before seen at the same time. In the USA alone, in the past five years, more than 40 million Boomers retired while a similar number of young adults entered the workforce. Another 40 million are about to enter the workforce or leave the workforce in the next five years as well. Having this level of young, tech-savvy workers employed is going to profoundly change the way we view the workplace. The old norms of hierarchy, on-time workplace attendance and 'office seat warming' are going to be challenged in every way. Additionally, 'Generation X' or the 'sandwich generation' (now in their mid-30s to late 40s, and so called because they are 'stuck between' ageing parents and dependent children, caring for both) are now predominantly in charge of – or being promoted at executive levels within – both public and private institutions. They are the true innovators, brought up in and still able to remember the old paradigm, yet now in the process of employing Millennials, who crave a more flexible workplace and culture. Most importantly the Generation X-ers are transforming all facets of our work and life culture by shifting from the Boomer focus on an 'outputs'-based work philosophy to a more innovative 'outcomes'-based one. This key difference means that it matters more that you get the problem solved creatively and deliver the outcome that builds value, rather than that you showed up to work each day on time and sat in your chair and did what you were told.

This transition to an outcome-based work philosophy is only set to increase as the median age group of workplaces shift and it will have a profound effect on commuting patterns. In addition, as Boomers retire they are not so likely to disappear from society and city life as their parents did. They have reinvented themselves, are volunteering and mentoring more, and maintain an even more active and social lifestyle than the previous generation.

4 Preferences for urban living and more flexible lifestyles

For the first time in human history there are more people living in cities than rural areas across the globe. Moreover, in the next decade we will see this trend accelerate and head on at a fast pace towards the 75%-urban mark. This is the beginning of the 'city planet'. The trend to migrate into cities is universal, making no distinction between developing and developed regions. In the most developed cities, particularly in the developed English-speaking ones, a shift is taking place from the car-oriented suburbs to the multimodal city centres.

Much of the demand for inner-city redevelopment is coming from Boomers who sell up their suburban house to buy a city-centre residence. As they age, Boomers are placing more value on the location advantages, rich cultural offerings and high-quality medical services that the city centre offers. Similarly, the Millennials, motivated by financial necessity (huge students debts and increasingly competitive, ever-rising rents) are moving into city centres, where the jobs on offer and the urban lifestyle are more culturally in line with their values. In contrast, Generation X, as they enter the child-rearing phase, are more likely to move to the suburbs but retain their urban outlook even as they raise their children, creating demand for increased clustering of urban amenities in suburban areas. In general, flexible hours, workplaces and lifestyles (no more just ‘Mum, Dad and two kids’ – think single parents, childless couples, same-sex families, and multi-generational/singles as the urban norm) will create even more demand for more flexible transport services and solutions to match.

5 Wi-Fi, GPS, sensors and smartphones

Modern technology that connects us and locates us has, more than all other developments, radically changed the possibilities of what we can achieve in transport service provision. Changes in how we can store and transfer data, and pinpoint and tag locations, and the ability to transmit large amounts of data virtually anywhere in a consistent format, have opened up a world of communication possibilities that were not possible even five years ago. Over the last ten years, first-phase applications such as bus priority, next-bus displays and pedestrian countdown signals using LED lighting have provided the first type of connectivity with networks. The result has been improved public transport reliability, reduced travel times, improved customer information, and increased safety and visibility for those on foot. Bus priority has reduced public transport travel time, while pedestrian countdown signals – first deployed in San Francisco in 2002 – have not only resulted in a 22% reduction in collisions, but also reduced the energy bill through state-of-the-art (at the time) LED technology.

Sensors and parking meters connected to networks have allowed the innovative first-of-its-kind San Francisco parking pricing programme called SFpark to become a reality. The realisation that almost 30% of San Francisco's congestion was due to people looking for somewhere to park pointed to the need for a different approach. Through the installation of sensors below ground at on-street parking spaces, linked to routers, the demand to park on those streets has been managed, through pricing, in a way that maintains a consistent level of supply at the lowest possible price to the customer. The pilot showed that keeping at least 20% of spaces available would cause the system to be in equilibrium. Using customer-friendly smartphone and Web-based applications to get people to the cheapest possible space directly, with payment via smartphone, was another novel development. The pilot resulted in a 30% reduction in both vehicles-miles travelled and greenhouse gas (GHG) emissions in these areas, as compared with the non-SFpark control areas. These technologies, put into place in tandem with good public policy, have resulted in this practice being emulated as a global best practice.

'Transport apps' (a term not really used five years ago) linking data sources to tell the user in real time when the next anything is coming/going, where it is presently located etc., have proliferated across the spectrum. Over a million apps exist for travel – giving information on anything from traffic conditions and transport options to availability and routeing, providing the ability to pinpoint and highlight whatever the user likes… the proliferation of functionalities never seems to end. In addition, mobile payment by means of apps that are more secure than ever before now allows vehicles/services to be both paid for and unlocked remotely. People like sharing everything about themselves, and their preferences. Call it narcissism if you like, but it is here to stay – and they enjoy playing games and competing against each other too.

'Gamification' is the name for app-based marketing or behavioural change campaigns that create the opportunity for people to compete with their neighbour or their school, workplace or social groups for a cause, and be rewarded financially, or with other rewards which they can then post, boast, donate or trade among their peers. The smartphone has single-handedly revolutionised perceptions of time and distance – and attitudes to last-minute delays and changes of plan – and redefined the connection to friends, work, place and 'self' in a community. Regardless of whether the device is the current rectangle, or becomes a wrist wrap, it is here to stay, and literally every segment of the market will have one in a very short period.

6 Anywhere everywhere connectivity

In addition to the technology convergence, the ability to reliably and consistently access one's information, and to pin/post/tag/upload/download virtually anywhere that networks exist across the city, region and planet has radically transformed people's idea of place and space. This means that there is no longer any real difference between the traditional workplace and a coffee shop, or indeed a Wi-Fi hub at any location, or anywhere that you have Internet connectivity and a mobile device. These sites are acting as de facto business sites, permitting anywhere-and-everywhere work and socialising. They are also creating the ‘work-all-the-time’ situation in which we are constantly connected – and, increasingly, expected to respond to colleagues.

7 Car driving/ownership preference changes

For the first time in the history of driving, the number of people of driving age applying for their driving licences in urban areas in the USA is dropping. In addition, the number of miles driven across the nation has dropped. This has sent ripples across the motor industry and awoken the sharing economy industry to the potential of new customers for their services. Younger people are choosing access over ownership for many reasons, but mostly for economic ones, and out of a sense of belonging to a community or service through the kind of membership that matches their values. Also, as the Boomers (the generation that celebrated automobile ownership and most closely tied their own cultural identity to it) age, they are beginning to get concerned about their ability to drive safely, being the first generation to witness their parents having to forego their licences because of safety concerns. This loss of mobility and, with it, their access to services, places, and friends and family, can be traumatic and lead to increased social isolation, especially for those in suburban or rural environments where everything is spread out, and walking, cycling and public transport are consequently not viable options. These shifts are creating a whole new demand for more shared and taxi-type mobility services in the short term, and are signalling the demand for driverless services in the longer term.

8 Travel as part of life experiences

As a result of the convergence of these technologies and a shift in cultural values, the journey and the destination are now less important than the need to be constantly connected. I have said many times that we don't consider texting as distracted driving – we consider driving as distracted texting! This highlights a whole new preference for being connected and communicating when inside a vehicle, rather than driving it and having to park it. Traditionally, public transport has satisfied this desire very well, as have taxis to a lesser degree.

People are social creatures, and whether you like looking at others or travelling with your friends IRL (in real life) (or virtually, by means of smartphones), driving just doesn't allow that to happen in a safe manner. Public transport and taxis have had an advantage in this respect in urban areas. However, thanks to the combined forces of demographics and intensified urban development, passengers have boarded public transport in droves, resulting in huge peak-period overcrowding. While public transport providers struggle with increasing operating costs of wages, pensions and benefits in the face of shrinking public subsidies, the capacity of the system is held back from meeting current, let alone future, demand.

9 Redefining transport through new street designs, service providers and systems

The seeds have been sown and the conditions are now ripe for a whole raft of transport options and services to emerge, grow and flourish. Over the past 30 years or so, streets in the English-speaking nations have looked more or less the same. However the past five years of street design, in the USA in particular, have seen a transformation. Once and for all emulating its cousins from Europe, many of the recent practices have not simply been transplanted from Europe's great public streets – from cities such as Paris, Barcelona, Copenhagen, Munich and Amsterdam – but have been readapted and redefined for a more US sensibility. These changes fall under the category of 'complete streets', where the priority has shifted from moving cars to providing spaces for people, and prioritising sustainable modes over driving. First seen in US cities such as Portland, which witnessed a tremendous growth in cycling, these ideas didn't really flourish until they were piloted at the scale of New York City, with its now famous closure of Times Square to create a space free from vehicular traffic. Since then, cities in the USA have been repurposing road space by adding green cycle lanes, red public-transport-only lanes, parklets (former on-street parking spaces converted to outdoor seating, global best practice that was scaled citywide in San Francisco) and public plazas. Walking and cycling have grown rapidly in these urban centres, with a growth that has been exponential.

Many of these designs were developed in spite of federal and state road plans and funding policies that favoured road design that prioritised high-speed automobiles. In fact, it was just a handful of US cities that formed a coalition under the name of the National Association of City Transportation Officials. This five-year-old organisation run by city transport department leaders has managed to do more educating among the traffic engineering and planning industry, and implement more street design change in the nation's big cities, than any other urban street movement. This "for-us-by-us" grass-roots movement begun by city transport departments (yes, the public sector!) has finally, after decades of begging by the advocates, led to a cross-disciplinary approach to streets which treats them as places for people.

They have jointly-developed products like the Urban Bicycle/Street Design Guides that showed and taught cities across North America how to make their streets more liveable for all users, regardless of their mode of transport, and acted as catalysts for neighbourhood economic development. These tools have spread across the United States, Canada and Australia in what were traditionally very car-oriented cities. These cities have worked together to share and learn best practices, and to understand the key tools needed to rethink and repurpose streets prioritised as people spaces for all ages and user groups. While cycling and walking are now at record levels in these cities, much more needs to be done to physically create a contiguous cycle network and to increase both walking safety and traffic intersections; many cities are finally adopting Northern European network designs, all the while learning and sharing from each other and exchanging ideas with many cities all over the world. This holds great promise for the aim of getting the street networks ready for the big shift to shared mobility.

In addition to changes to street design, there have been simultaneous linkages to new service providers that fit neatly among, or challenge, these new street designs. These service providers come in various shapes and sizes, and will go through a metamorphosis over the next decade. Since the early 1970s, carpooling has been seeing a slow but steady increase in usage, where people privately carpooled with another person – incentivised by the US federal government, which provided dedicated lanes on highways or free access at tolled bridge crossings for cars with at least one passenger. Considering that on average four of the five seats in cars are almost always empty, it has to be said that cities and transportation governments didn't really take a big-picture view and look at what they could do to fill those empty seats. A small shift in vehicle occupancy can have a dramatic positive impact on congestion and travel-time reliability, and reduce the need for new infrastructure. These services had been given a little funding for operating vans (termed a 'vanpool') between employees for the journey to work and back, and carpooling expanded a little in the 1980s and 1990s. Since then, however, carpooling has been seeing a steady decline across the USA. A whole raft of reasons lie behind this, from demographic changes, to two-parent working families with multiple needs, to smaller households. Carpooling holds such great promise, but governments have failed to lay hold of its potential.

Since the early 1990s, car-sharing (short-term rentals of vehicles shared among members) has been undergoing a slow but steady increase too. Only after the changes mentioned above has car sharing flourished in urban centres in over 200 markets. Zipcar is by far the largest traditional car-sharing service (offering a service where the user picks up and drops off the car in the same location, and pays by the hour) and now Car2Go and DriveNow, both companies from German car manufacturers, offer one-way car sharing (which means that there is no need to bring the vehicle back: the user has only to drop it off at a designated space or location, and pays by the minute). Scoot, a scooter-sharing service unique to San Francisco, and MOTIT in Barcelona, are also growing, albeit at a slow, but steady, pace. Similarly cycle-sharing, a virtually non-existent concept a decade ago, is flourishing in nearly 1,000 cities, and growing exponentially.

As more providers have opened up, there have been a few apps that have acted as aggregators of the wealth of services in each urban market. Amongst these are RideScout and TransitScreen, which have both offered these services to aggregate providers. In a way that resembles the travel website Kayak, which finds you the best airfare, hotel and car rental, so too these services discover the best route and the right mode based on user preferences. In some cases, employers have taken matters into their own hands by providing private employee transport where the regional public agencies cannot, or will not, provide a service. This controversial service has taken policymakers by surprise and raised questions about governance and the roles of the public sector and private sector in urban mass transportation.

In San Francisco, and in cities in the tech hubs of India and other select urban markets, some employers are providing a private commuter bus service to pick people up from the most urban areas of the cities and take them to the outer suburban office parks, as their staff either live far away, or – in San Francisco's case – refuse to live in the outer suburbs, preferring the 'coolness' of the city. So, by competitive necessity, employers such as Google, Apple, Facebook, Yahoo and Genentech are providing this amenity to attract and retain employees. These companies spend hundreds of millions of dollars each year to provide what is a private regional limited express commuter bus service that the regional government is not willing/able to provide, and thus they fill in the gap. However, these services are available only to employees of these companies, and so are frustratingly off limits even to someone working in the next-door office. The reasons for this, the employers claim, centre around privacy issues – although this argument has been debunked, as many of their other employees travel alongside each other in the heavily crowded commuter train and local bus services that connect them to their workplaces. The sudden increase of tech employees residing in the city has not been well received by affordable housing and social justice advocates, nor by policymakers who claim that these services are "exclusive, and cause gentrification" in the cities that they serve, even though many of the employees are actually long-time residents of those cities.

The policymakers were caught in reactive mode, and had to determine whether these services support or hinder our transport and community goals, and what – if any – is the right mechanism whereby companies should be asked to pay their fair share for the transport service's perceived – and real – impact on the local street traffic and public transport stops. Governance and data are key issues that policymakers will still struggle with in relation to these new and emerging services. Many companies – for example Twitter, Uber, Square and Salesforce – reside in the city and claim to enjoy a competitive advantage in that location because the short commutes of their employees allow for more interaction at work and better employee happiness than would be possible if they were in an outer suburban location, which would mean, even with a shared luxury bus journey, a two- to three-hour daily commute.

Nothing has been as disruptive or as controversial in recent transport history as lift-sourcing providers, referred to in California as transportation network companies (TNCs). These include Uber, Lyft and Sidecar, and there are many other such companies throughout the world. What makes Uber most interesting is its global ambition to provide the service in every conceivable market, and through their app to create access to the same service no matter where in the world the user finds themselves (as long as Uber has a service in that market). What they have managed to do by linking on-demand services with cashless smartphone booking and payments has sent ripples across the taxi industry, creating a series of regulatory knee-jerk policy and regulatory reactions not seen since the jitney days of almost a century ago.

Currently in 1.0 phase, these systems are not interconnected and are too small to have any ability to bring about a major modal shift. Car manufacturers such as Daimler and BMW, and car hire companies like Avis, have already moved into the sharing service arena, and more will no doubt follow. Taxis and TNCs are so competitive that they are cannibalising each other's markets at the moment, and are failing to grow the overall 'pie' of trips as much as they claim to; however, they have more access to capital than any of the other shared providers, and may grow faster as a result. Only recently have these companies come into the liftsharing arena – amongst them Carma and Carpooling.com – offering longer-distance commuters and intercity travellers the opportunity to carpool in close to real time. The holy grail of commuting has always been to get access to real-time lift sharing, which offers the promise of linking people to other travellers who are already underway, to increase occupancy and reduce congestion in the urban core. Just this year Uber and Lyft launched their real-time carpooling services in San Francisco and Los Angeles. While still in their infancy, these services offer a discount to the regular price of the journey if you're willing to share it with others along the way.

Of all the services on the scene today, these seem to be among the most promising for scale in urban markets. Again, nothing has stopped the cities that regulate taxis from permitting taxi-shared journeys, especially along crowded bus lines and to and from airports (the most lucrative of all taxi trips), and this is just another example of the formulation of policy that not ready, or willing, or able to match customer demands.

All told, these shared mobility services offer great potential for augmenting the heavy line-haul public transport services by offering first-mile to last-mile connectivity, and filling niche gaps where these services don't make the most economic sense. However, in their current form they all run the risk of becoming too diversified in the absence of any interoperability or interconnectedness, and will give rise to a mishmash of mobility options that might not be able to scale to the needed level for their potential, and may well cannibalise each other, or peak only to fail, thus missing tremendous opportunities for market capture and the depriving urban transportation of great benefit.

10 Major trends in the near future

Looking at the trends that I have just outlined, one can see that the last five years have been truly transformative for the transport system as a whole, and can go on to predict that the next ten will see change on a scale that we can only just begin to imagine… and yet some things will stay exactly as they are – or, worse, deteriorate. I will now attempt to highlight what I believe to be the major anticipated trends in transport. As I said, events could go in a different direction, but it is up to us to make sure that the direction we want is sustainable and accessible, and to avoid making things worse.

The next big trends are going to be major game-changers, and they are going to be led, supported and managed in cities, as opposed to by regional or national governments. These trends will be felt first and foremost in the cities that have experienced most of the seven previous trends already in place, and will be quickly followed by the rest.

Cities are more connected with each other than ever before, and yet the one thing I have noticed is that they are fiercely independent and competitive. The key reason for this is that in order to keep that economic competitive edge that attracts and retains the best talent and services, they need to be 'on their game' all the time, as the requisite shifts can happen quickly.

Cities that have been working hard to create these liveable, mixed-use communities, with a healthy supply of housing with inviting complete-street designs are on the verge of hosting the greatest innovations yet to be seen in the realm of transport. If they can adjust their policies from being reactive and knee-jerk to being more open and collaborative, operating under a fair-governance principle, we will see these innovations happen all the sooner, and in greater numbers globally. The urban transport trends over the next five to ten years can be categorised as follows:

- Synchronising and connecting every network
- Performance-based public–private partnerships becoming the norm rather than the exception

- Diversification and consolidation of transport manufacturers and providers
- Modular, combined shared e-mobility systems to scale in urban areas
- Commercial deliveries and the phased introduction of drones
- Driverless vehicles and their potential
- Mobility as a subscription service, with routeing, booking, payment, unlocking, gamification and trading

10.1 Synchronising and connecting every network

As the ‘Internet of everything’ matures, cities will be more open to connecting their networks with private networks, including traffic lights, public transport, parking facilities, commercial fleets, private automobiles, and shared mobility providers. In vehicles, stations, bays, and at intersections, sensors will be installed on every conceivable service that cities and businesses provide. These sensors will be counting, recording, calibrating and predicting various types of nuanced urban conditions (for example learning that certain areas have a higher likelihood of being frequented by pedestrians or children, or being the site of construction, special events and so on, so that they can be ready to deploy early detection warning or navigation systems), to notify each other so as to minimise congestion, or crowding on public transport vehicles; to optimise routes for delivery of services; or, in the event of an emergency, to reroute people to safety. These systems will require a concerted effort to achieve internal and external coordination that is not so much technical in nature as collaborative. The opaque governance of the past will need to give way to a new, more open governance, with leadership from a younger, more agile work culture that is more open to trying, testing and piloting ideas in order to establish a fully networked and synchronised multimodal system. These networks will display, in real time, the conditions that matter to city departments, companies or an individual through their customised apps, and will demand a workforce charged with procuring the right set of tools to optimise and connect all networks.

10.2 Performance-based public–private partnerships becoming the norm rather than the exception

As public transport budgets dwindle, and no concerted effort is made to replenish them with unpopular taxes and user fees, cities will be forced to make some very hard and vexing decisions. Do they focus on operations and maintenance only, forgoing the expansion of capacity? Or do they prioritise the higher-capacity routes and abandon the lower-volume ones? These trade-offs have serious implications touching transport policy and governance, not to mention ones concerning potential social equity. Public agencies are at crossroads, facing both an urgent financial need and a pressing policy requirement to be relevant and grow at the same time. Those that decide that this is a false dichotomy, and that through public–private partnerships (PPPs) they can achieve a ‘bit of both’, will be poised to succeed, as these basic networks are the backbone of the cities' transport systems and must be protected, maintained and strategically expanded. For this to materialise, there will have to be a transition whereby the public sector reduces its operating role and moves towards oversight and performance management to ensure accessibility and universal design standards in these PPPs. Many of these issues are exacerbated by the 20th-century funding paradigm of encouraging expansion while making little or no provision for operations and maintenance or demand management.

Cities and transport agencies will be forced to shift from this unsustainable practice, and focus instead on demand management and expanding strategic capacity. This will represent a wholesale change in how transport has been delivered over the last century. The result will be a more transparent and performance-based view of the transport system; PPPs will come in all shapes and sizes, from infrastructure, service provision, operations and maintenance contracts to marketing, design and project delivery. All facets will need comprehensive redefinition, with a focus on reducing inefficiencies in the entire planning, design, delivery, finance, procurement processes, right through to operation and working conditions.

Many of the subsidies needed for both road and public transport will either be reduced or end up being overwhelmed by the state of disrepair and the large amounts of capital consequently required to fix the infrastructure. The focus will thus need to be on maintaining capacity through demand management and levying charges from developers involved in land-use developments, as it can be demonstrated that there is a close connection between developments in cities and the impact that they have on the local and regional transport network. San Francisco and other cities, particularly Hong Kong, have pioneered these leverage and value-capture agreements to pay for infrastructure, rolling stock and other eligible facilities. These agreements to fund and manage demand provide a win–win solution, in that the fees from these developments build on the multimodal network and pay for the rolling stock, in addition to dedicated maintenance and operations for public transport in order to increase both supply and frequency. Performance-based contracts will require a certain level of access to be provided to the road and public transport network, and payments will need to be based on customer service metrics, including increases in public transport ridership and reductions in peak-hour vehicular traffic. This in turn will increase the ability of shared modes to flourish, as they provide more niche-market solutions, and first-and-last-mile connections in urban and suburban centres.

10.3 Diversification and consolidation of transport manufacturers and providers

The next decade will see an even greater global migration to cities, at a scale never before witnessed. The needs for transport in these cities will be correspondingly immense, and the traditional options will take too long to implement and reach the point where they address the needs. Similarly, in the more developed cities, public budgets will continue to be overwhelmed by spending on wages and benefits, and unless new revenue sources are developed, projects that increase capacity will take a back seat while agencies struggle with operating costs. The need to provide flexible transport will be less of an ideological policy issue and more of a pragmatic economic necessity. The role of public agencies will have to shift away from operation and delivery, towards overall governance. Smaller, more nimble companies will flourish, until the end of this decade. These will include car-share, cycle-share, scooter, motorbike, minibus/jitney, privately provided commuter transport, e-mobility and taxi-like service providers. A period of diversification and customisation based on urban demographics will become widespread around the world, in every city. These services will not all be truly synchronised, and will thus require multiple subscriptions to access them; no single provider can alone raise the capital needed to scale up so as to meet the demand for the entire urban market. However, as soon as a few show promise of scale, a series of mergers and acquisitions will take place to consolidate them. These acquirers will most likely be the more innovative transport, technology, energy and telco companies, for the following reasons:

- It is these companies that are already experimenting in this arena and acquiring companies/staff with the relevant expertise.
- The vast amount of capital and widespread presence that these companies have in the world's cities is unparalleled, so they will be able to quickly add these business units to their portfolios.
- The transport industry has an unrealised value proposition that is in the thousands of billions of dollars a year – if matched with technology, energy and telco solutions.
- The service providers will in all probability be able to merge these services to offer a single package for customers that looks somewhat like the mobile phone plans we are familiar with today.

10.4 Modular, combined shared e-mobility systems to scale in urban areas

One of the more interesting trends of the next decade is going to be the combination of shared mobility services (such as car-, bicycle- and scooter–sharing) throughout the urban market, linked with an 'aggregator' app that can route, book, pay and unlock these services in a way that can be customised to suit individual user preferences. This trend will be an outcome of a few major changes over the next decade. For example, privately owned cycle usage will grow and most likely peak over the next decade in US cities (as has private car usage), then giving way to shared services owing to the advantages and convenience of access that they provide, and the fact that they do away with the hassles of finding secure parking, a problem that has led to the cluttered-up streets that are endemic in the world's cycling capitals such as Copenhagen and Amsterdam.

In addition to more bicycle sharing, we will see the evolution of on-demand app-enabled shared private shuttle services. These are the 21st-century version of the early 20th-century jitneys that were eventually outlawed in developed cities and replaced by public transport, and will provide niche services in the public transport market in developed cities, as well as dramatically improving the existing informal systems that provide the majority of shared transport in developing cities. They will become more like Uber and Lyft, but with shared vans, and will fill in the gaps currently existing in neighbourhood access, and provide solutions for corridors where public transport does not exist, often because it has not been practical. Services that are already taking off, such as RidePal, Bridj and Helsinki's Kutsuplus, will grow.

Shared mobility services have been shown, when deployed, to change travel behaviour and augment public transport. On average, one car-sharing vehicle has been shown to replace the need for about six to ten private vehicles (the number depending on the market in question). At this ratio, an optimised sharing fleet can fully replace 60–90% of the private car fleet, which sits idle about 23 of the 24 hours in the day. That is a staggering proposition for car manufacturers, who would have to rethink the value proposition of their business model.

For San Francisco that means that, in order to replace the current private fleet of c.400,000 vehicles, the shared fleet size would need to grow from the current c.1,500 shared vehicles to about 40,000–100,000. Of course many people will hold onto their cars during this next decade, but a fleet of this size would create a huge sea change in terms of modal shift, in all urban markets. Optimisation of the fleet would allow a further reduction in the private fleet size, with taxi-like services such as Uber and Lyft taking on a much larger role, alongside a proliferation of more diverse vehicle types, such as scooters and bicycles, that meet trip-type needs that today's cars don't. Most successful networks of sharing pods (publicly accessible locations reserved for the parking of cycle-sharing or car-sharing vehicles) work at a scale of a 300 m^2 grid, so they are ubiquitous, visible and convenient. Cities have allocated so much street space for idle cars (on average 20% of the city's open space is covered with asphalt), and on-street kerb spaces could provide a great amount of that space for pods of two or three spaces positioned next to next to public transport stops that could hold a few cars, cycles and scooters. For San Francisco that would mean converting approximately 10,000 spaces for these pods out of the estimated 250,000 on-street spaces in the city.

Even more promising are the co-benefits of that demand management with the economic and environmental benefits of an all-electric shared mobility – or 'e-mobility' – fleet (electric bicycles, scooters and small electric cars). Range anxiety is the key barrier to entry for most people when it comes to electric cars. Having ubiquitous charging throughout the city would greatly reduce that barrier, and if free charging (not free parking) was included, that would create an even greater incentive to switch to electric. The most interesting prospect is not converting the current internal-combustion engine fleet to electric, but the combined synergy of ubiquitous modular solar-charging facilities linked with shared e-mobility and battery backup units. This would have the multiple benefits of reducing GHGs, noise, traffic, and transport costs, while at the same time increasing access to more mobility options for all users of the transport system. A change like this will finally start to close the inequity gaps created by providing so much public space for private cars. In addition, this would be a viable solution to the need for a secondary supply of energy and backup to the grid in case of emergencies and disruptive events. It is not clear if the future economy will create more wealth, so it is going to be especially important to come up with more affordable and resilient transport choices. The combination of a shared e-mobility fleet with modular solar power canopies such as those made by Envision Solar, which have autonomous tracking to optimise power, would represent a win–win situation for several reasons:

- E-mobility would dramatically cut down on GHG emissions, energy consumption and noise in the urban transport sector.
- E-bicycles have a more universal appeal to all ages and fitness levels, and can assist in climbing steeper hills and covering longer distances which, in most cities, constitute huge barriers (alongside the need for a contiguous network) to growth in cycling.
- Shared e-mobility results in a twofold beneficial effect, reducing GHGs and noise by reducing the fleet size of the overall transport system, and also providing access to many e-vehicles at a fraction of the cost of owning each of these units.
- The solar-powered pods fit neatly inside a standard kerb car-parking space and can provide a top-up charge for e-cars, e-bikes and e-scooters.
- The solar canopies with battery storage can also act as a supply of distributed and backup energy in emergencies for neighbourhoods and the grid, addressing one of the most vexing issues for urban-area utility companies today.
- The modular set-up can consist of one unit or include several in a row, and has the lowest capital system installation cost, requiring no wiring or trenching, and obviating the time-consuming chasing of permits needed from various parties.

The modular solar canopy with battery backup, tethered with Wi-Fi and shared e-mobility services, would create a system that would be quickly scalable in any city. This autonomous solar panel sun-tracking feature and modular capability would allow the system to be located and tested to optimise the solar panels' density; the system can then be incorporated into a city's parklet programme and managed by the adjoining business. The combination of the modular power system and the shared e-mobility service would truly revolutionise the way in which rights of way are managed in the street. Tapping into the essential nature of the travel demand that these shared services cater for would free up space for walking, cycling/bus priority lanes and for general use.

The key will be the modular nature of these services, which means that they offer the greatest flexibility and scalability in the shortest time and most cost-effective manner possible. As the first of these types come on board, the consortium companies, through original equipment manufacturer (OEM)/telco data/supplier/operator/utility partnerships, will begin to consolidate the myriad services, scaling them to the level that will make modal shift possible. The connection to an aggregator app that can link to this system for both transport and energy will in reality create the system that both companies and individuals will find to meet their daily transport and local neighbourhood energy needs. Eventually, space will need to be given to people, not to their private vehicles, regardless of the mode. This is where the opportunity for shared mobility holds such great promise.

10.5 Commercial deliveries and the phased introduction of drones

Commercial delivery has undergone radical logistics optimisation, and the recent introduction of pick-up/drop-off boxes at key sites in cities has just started to scale. These services will expand into every major railway station, and then into places like local bus stops, post offices, schools, libraries and community centres, providing facilities where people can pick up and drop off their deliveries at their convenience. Supermarkets will soon be doing this too, offering people the ability to pre-shop and pick up, enabling reductions in store size, a diversification of locations, and ultimately fewer commercial delivery trips in cities. In addition, it is only a matter of time before cities will require these service delivery vehicles to switch to all-electric, then become smaller in size, then focus on light electric vehicles such as e-cargo bicycles and e-cargo scooters; in this way, delivery services such as Google Shopping Express, AmazonFresh and Uber will be able to satisfy their customers' 24 hour-a-day demand for deliveries.

However, these service changes to urban goods movement will be dwarfed by the introduction of commercial delivery drones. These will have profound implications for the just-in-time anything-from-anywhere experience in urban and suburban areas. The key issues that policymakers will face are: How high or low should they fly? Where do they land? How do they land in areas with lots of overhead wires? Who would be responsible for collisions with people and property? Or for the theft of parcels? There are so many issues to think about with these game-changers for service delivery providers such as FedEx and UPS, Amazon and Google Express. Regardless of these issues, they are coming – and they will become part of everyday life for many businesses and customers.

10.6 Driverless vehicles and their potential

There has been so much hype about autonomous, or driverless, vehicles that many people are convinced they are already here. Well, they are and they aren't… and over this next ten-year period we will start to see a series of appearances of autonomous vehicles in various applications. We have had driverless trains for a few decades now, and they have become the best practice for new urban metros like those in Copenhagen and Vancouver. We also had a series of experiments wherein the US government tested connected vehicles in platoons in California. It seems that commercially scaled driverless road vehicles will arrive in phases, and have the potential to simultaneously satisfy and challenge our needs for sustainable mobility.

The first phase has already started – the synchronising of private fleets with commercial fleets on every conceivable network, to optimise their performance (and carry out vehicle maintenance checks). These connected vehicle systems, if executed properly, will interact with parking information, traffic, physical road conditions, construction detours and weather networks. They will learn predictive travel and routeing options for the purpose of optimising fuel economy and travel time. This phase will introduce pre-emptive adjustments to driver behaviour – in other words, the vehicle will intervene with faster reaction times than human motor skills are capable of, to avoid collisions and ensure that speed limits are observed. This will be of most importance in urban areas that have adopted low speed limits through their 'Vision Zero' traffic safety policies.

This phase will also include adaptive learning by the vehicles about their surroundings – they will be able to collect data by experiencing a variety of environments, such as rural, suburban or denser urban conditions. It is in this phase that we should see a greater reduction in fatal vehicle-to-vehicle and vehicle-to-pedestrian/cyclist collisions.

The second phase will consist of partial automation, and will be confined to closed fleets that serve large distribution centres and/or facilities such as airports, military bases, ports, theme parks, campuses and the like, but will not normally be seen on open roads. Once they have proven their effectiveness, the third phase will come in.

At the inception of this third phase, there will be major policy issues to deal with, such as insurance and transitional fleets, with manually operated vehicles mixed in with automated fleets. The potential promise of this phase is manifold:

- There will be a greater ability to maximise the operating resources of public transport by phasing in driverless small buses for lower ridership lines, or for areas that are suburban and lower-density, and are not currently served by public transport.
- Public transport agencies, by using driverless buses, could potentially increase service frequencies, save on operating costs or make current budgets and staffing levels go farther.
- Fatal and severe crashes would be eliminated almost entirely in cities.
- Vehicles would be linked to urban highways and 'freightways', providing complete synchronisation with traffic and emergency events, and demand-management optimisation.
- Driverless vans would replace almost all lower-performing public transport lines, allowing the agencies to focus on higher-demand routes.
- Car ownership and driving would be drastically reduced in both urban and suburban areas, with optimised on-demand services meeting almost all mobility needs.
- Driverless e-mobility would provide the biggest reduction in GHGs and other emissions, through demand management and optimised routeing.
- Accessibility in urban areas would increase for people who cannot drive owing to age, ability or income.

While these options are the most preferred, the cautionary note to sound is that business-as-usual could prevail, and car manufacturers or technology companies could create a scenario of privately owned driverless vehicles that clog our streets and highways with frivolous deliveries and 'deadheading' to and from home and workplaces. These would be tremendously inefficient and expensive to service, so would benefit only the wealthy at the exclusion of others. As a policy matter, it is most important to support driverless electric vehicles for shared use in a way that meets the many and varied sustainability needs of urban and suburban areas.

10.7 Mobility as a subscription service, with routeing, booking, payment, unlocking, gamification and trading

When all these six trends converge, we will see a new set of companies that will be able to provide the equivalent of mobile phone data plans, but for transport. This subscriber-based 'mobility minutes' system will take on the key areas needed to make this whole sum of parts work. An app would link into all services in the urban market, to provide options for local, regional and global access to mobility minutes. One example of this service would be the ability to pay for instant, hourly, daily or monthly access-minutes, which are subscribed to individually or as part of a group mobility access plan. The minutes of access would be weighted by the cost of providing that mode and the sustainability or economic costs/benefits which the mode provides to, or costs, the city. This plan could look like this – for US$100 a month you get access to a choice of:

- 30 peak/60 off-peak driving or taxi minutes;
- 300 peak/600 off-peak public transport minutes;
- 300 scooter minutes; or
- 1,000 anytime cycle-share minutes.

Moreover, every minute of walking would top up your mobility minutes. So you can 'recharge' when walking between trips, and to certain destinations. You would be able to trade/donate minutes locally or globally for credits for other travel purposes which demand higher levels of minutes, such as limousine services, intercity train travel or air travel. These aggregator apps would link the mobility minutes together as a form of payment, obviating the need for credit cards or other forms of barriers to entry.

Multiple partnerships will emerge between retailers and hospitality, facilities, education, health, energy, telco and service providers, with rewards/incentive programmes to tailor the market to individuals on the basis of adaptive learning, user preferences or user behaviour.

Here is a step-by-step outline of how the app would work:

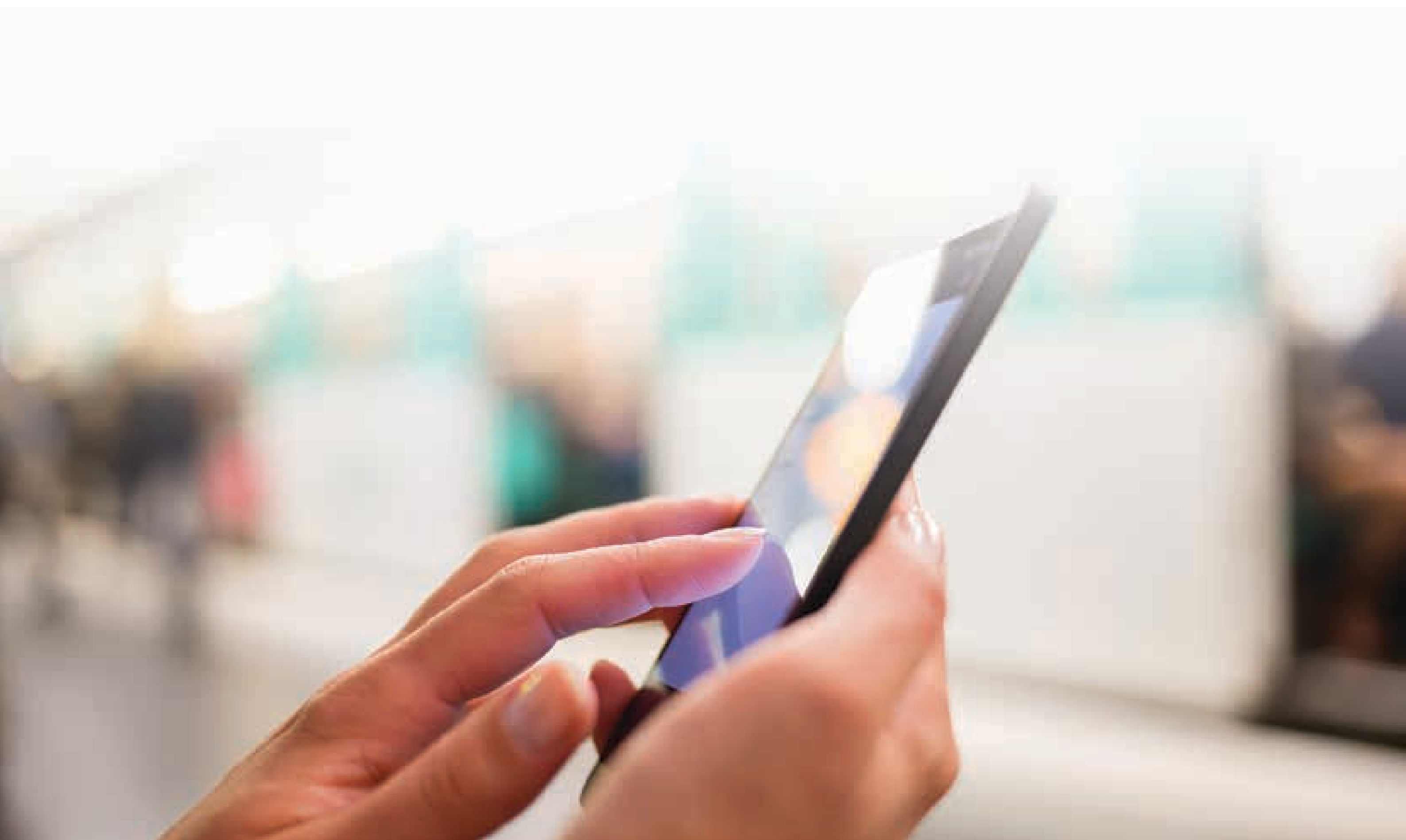
- You will select your current location and choose your destination.
- You will then identify the mode and the cost (which will involve the predicted travel time in minutes, and the cost – whether peak or off-peak) that you prefer.
- You then book the mode.
- Once you have chosen, the app will upload your mobile ticket, or it will unlock the mobility device – whether car, scooter, bicycle or other.
- During your trip, information about your preferences, special dates or friends will be displayed, to inform you of where your friends are, your favourite purchase items that may be on sale that day or at that particular time, and/or your favourite foods in case you are hungry.
- The system intelligence will become exponentially more sophisticated, and will start to understand and predict your travel and other lifestyle preferences. This is the first step towards artificial intelligence in mobility.

- Once you complete your trip with that mode, you simply exit the vehicle, which signifies the end of the trip, and you will then be given analytics based on what you value; this might consist of your credits or be based on a points system – you can then decide to top up, trade or report as part of your gaming experience, in which you are competing with your family member, friend, neighbour or workmate across the globe.

- You may be a participant in a rewards system that gives you elite status, in a manner not dissimilar to the Star Alliance for frequent flyers, or you may reach a threshold in a points system and receive instant rewards like movie tickets if you choose a sustainable mode rather than single-passenger driving. The potential is limited only by the imagination of the app developer.

- At the back end, the analytics will be made anonymous and will be aggregated to provide real-time analytics of transport utilisation, and operations and maintenance, for use by city data scientists and policymakers.

Because the system will be global in nature, people will get more credits for their sustainable travel behaviour, and can trade those excess credits for retail, food and utility purchases with more travel-intensive subscribers, creating a win–win situation for all subscribers to these networks.



11 Conclusions

The future of mobility is being pushed forward by rapidly shifting demographics arising from Baby Boomer active retirees, Millennials entering the workplace, and Generation X as both innovators and parents. These forces are creating a wholesale change in the way we view ourselves and our workplaces, spaces and travel needs. Ubiquitous connectivity allows us to connect and work from anywhere and everywhere, all the time. Our journey will continue to be valued as an experience to connect with our surroundings, rather than a means to get from A to B. Transitional technologies and social media are bringing together the many disparate elements of our lifestyles, and we are entering a new phase of interconnectedness.

There is significant pressure for original equipment manufacturers to realise that this new sharing platform is going to be necessary for survival. Government also will need to realign its focus on core capital infrastructure through PPPs in select urban markets. Unless we gather new revenue sources, most urban markets will focus the majority of their public expenditure on maintenance, abandoning public-only-financed expansion. We have entered the era of mass diversification of service providers, and this will be closely followed by mass consolidation among cross-platform systems and sectors through emergent new companies. We are going to see a phased increase of pick-up/drop-off lockers at neighbourhood centres, and the introduction of service delivery drones, connected vehicles, self-driving vehicles (in limited applications), connected traffic, and payment and booking systems. Transport will evolve to become a subscription service, with highly customised mobility menus catering to users' individual preferences and tastes. People will purchase mobility minutes for local, regional and global options.

The seven trends that have characterised these last ten years have informed the seven major trends that will emerge over the next ten, and this will completely transform our concept of urban travel. I cannot emphasise too strongly that this convergence involves a complex system of parts, and will require unprecedented cooperation and collaboration on the part of both public and private sectors. If we get it right, we will see a more sustainable, affordable and connected transport system that will exceed our expectations and meet our sustainability needs for the next generation. We are at a crossroads, and the choice is ours to make: do we want a transport system that is safer, more resilient and accessible to all? Or are we going to slowly watch the decline of our systems, all the while adding more polarising technology to the problem? Let's choose the former.

The Royal Automobile Club Foundation for Motoring Ltd is a transport policy and research organisation which explores the economic, mobility, safety and environmental issues relating to roads and their users. The Foundation publishes independent and authoritative research with which it promotes informed debate and advocates policy in the interest of the responsible motorist.

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