OPPORTUNITIES AND CHALLENGES IN TECHNOLOGY

Introduction

The pace of technological developments affecting travel and road transport is increasing – in automotive technology, in road and traffic management systems, in information available to travellers and in new transport services ('mobility as a service'). It has the potential to bring about transformative consequences for travel choices, for the safety and capacity of networks, and for network maintenance and management.

This Supporting Document presents a selective analysis of the different elements of the changing technology landscape as they are seen to influence the operation and management of the Major Road Network and the choices and behaviour of its users.

The analysis and commentary that follows is drawn upon for Chapter 7 in the main Study Report; note that for Connected and Autonomous Vehicles (CAVs) the entire commentary is presented in the main Study Report, due to current levels of interest in this subject, and so the topic is not covered in this Supporting Document.

Types of technology change

Table SD10.1 below presents six types of technology change, and plots our view of the transport system changes they are expected to cause, the likely effects on demand and travel behaviours, and the resulting effects on the road networks and the environment. It is also reproduced in the main Study Report as Table 7.1.

Table SD10.1 Summary assessment of the impact of technology types

Technology changes	Changes in the transport system	Demand impact – travel choices and behaviours	Effect on the networks and environment	Timescale
Wide range of non-transport technologies reducing the need to travel or ship goods (eg video conferencing, 3D printing)	(No direct changes in system)	May remove some journeys altogether	Some reduction in traffic flow	Many of these technologies already well-established; further potential remains uncertain over coming decades
Better, more integrated information for travel choices, routes, journey-times, congestion, incl. for delays and incidents	Network operators can influence driver choices	Enables optimisation of travel arrangements and times; mitigates congestion effects; may stimulate new demand	May mitigate some delays and congestion, especially that related to incidents, and on interurban networks	Well established developments, continuing under market pressures
Levels of automation of vehicles (Connected and Autonomous Vehicles - CAVs)	Vehicles with progressively higher levels of automation entering into the UK vehicle parc. Uncertain rate of	Impact uncertain but probably positive response to increasing automation, raising demand especially in	Uncertain outcomes depending on how risk levels are set and the behaviour of drivers in mixed flows. Studies	Higher degrees of automation – but still with driver in control (up to Level 3) – may be widespread by 2025; Beyond that,

	adjustment by network operators to accommodate change and realise benefits	later stages of autonomy. Some demand likely to be stimulated by less stressful journeys, and eventually from non-drivers	suggest some modest capacity benefits for urban and inter-urban roads. Big improvement in accident rates and road deaths.	uncertain rate of progress and market penetration, towards full automation. Governed by a range of behavioural, legal and other factors
'Mobility as a service' – emergence of tailored transport, travel-on-demand	Digitally-facilitated new services emerging (eg Uber, car-2-go) which do not require car ownership. Change generally unforeseen and disruptive to existing markets	Evidence so far suggests increased use of new services, and may lead to reduced car ownership	Likely that supply will increase in response to demand where density is viable; mostly an urban effect, likely to worsen congestion	Innovation already visible today, mostly confined to larger cities. Likely to become more widespread in 2020s, but viability may be limited by population densities
Changing how road networks are managed	Optimisation of capacity, and influencing driver behaviour; improved efficiency of asset maintenance	Smoother network performance experienced by drivers: may stimulate demand; better driver information from network operators	Ability to increase capacity and throughput, reduce unpredictability, from influencing drivers' decisions. More cost-effective asset management	Network management methods are mature, but will be more widespread; extensive engagement with drivers from mid-2020s
Improved emissions of vehicles	Vehicles with reduced carbon emissions and emergence of hybrids and non-fossil fuel vehicles. Reduced NO_x and particulate emissions, coupled with controlled access zones (CAZs) excluding or pricing out non-compliant vehicles	Pricing and regulatory measures will nudge drivers towards the take-up of these cleaner and less-polluting vehicles	Contribution towards greenhouse gas emissions targets; better air quality and compliance with air pollution limits, leading to better health outcomes	Some uncertainties still about the degree of carbon emission reduction by the 2030s. Air pollution limits expected to be achieved from 2020 outside London; from 2025 in London; conditional on effectiveness of CAZs

Non-transport technologies affecting the demand for travel and transport

The effects of digital technologies on people's workstyles - telecommuting, part-working at home, and of more dispersed location of certain kinds of businesses – is a well established trend over the last 15+ years. The effects have already been seen in the flattening off for commuting in many markets and the stabilising or decline of peak period traffic in town centres over the last 15 years. Effects on longer distance travel (and thus on travel demand on the major road network and on intercity rail) are not so clear; there are some suggestions that the net effect on business travel may be to increase it. The longer term effects as devices and capabilities of data handling become more sophisticated are difficult to anticipate and chart.

While there are many aspects of demographics, attitudes, lifestyles, incomes, and so on which are driving changes in personal travel demand, we need to understand as part of that the extent to which the widespread effects on lifestyles of digital technologies at the personal level may be driving changes as well.

A paper by Professor Glenn Lyons at UWE[1] scoping out *Transport's Digital Age Transition* suggests a broad range of possible interactions and consequences, and in the reference lists where research has been carried out on these effects. He describes how the use of ICT can

- Substitute for travel (an activity is undertaken without the individual needing to make a trip)
- Stimulate travel (information flows can encourage new activities requiring travel – including second-order effects from substitution
- Supplement travel (increasing social interaction without increasing levels of travel)
- Redistribute travel (for example re-timing commuting where some of the day is worked at home)
- Enrich travel – opportunities to make worthwhile use of time while travelling;
- Indirectly affect travel (where changes to lifestyles and locational decisions in turn affect the nature and extent of travel)

We believe that these effects are likely to be profound, pervasive, progressive over time, greatly varying in their impacts between different groups – and challenging to research, quantify or forecast.

For example, it is suggested that the transformative effects of digital technology on young people's lifestyles and travel behaviours are not being fully comprehended or taken on board. Up to 15 years ago socialising meant getting together – or using a landline phone. The internet, social media and smartphones have completely transformed the way social interactions of the younger generation in particular take place, with wide anecdotal evidence that trip-making for social purposes has fallen; and, coupled with the cost barriers of acquiring driving licences, and of owning and running a car, it has affected licence holding, and car ownership and use. At the same time, this is the generation most likely to adapt to the way technology can facilitate the sharing economy, whether informal such as ride-sharing or commercial as in Uber.

While such effects are more likely to influence shorter, urban journeys, the effects on longer-distance travel – whether by rail or using the Major Road Network – are more elusive. This is a challenging area to comprehend, and research, but it is important to keep track of changing lifestyles and impacts of digital transformation on travel behaviours and attitudes.

Better and more integrated information for travel decisions and new business models

[1] *Transport's digital age transition*. Glenn Lyons, University of the West of England, *Journal of Transport and Land Use*, 8 (2). pp. 1-19, 2015

The ways in which digital technology developments are influencing so many aspects of travel and decision-making are widely understood, from journey-planners to smart ticketing, from satnavs in the car to real-time in-journey information about rail or bus services.

In London, where the Oyster card is highly integrated across (non-car) modes of travel, and journey information is relatively sophisticated, the high rates of growth in public transport ridership can in some part be attributed to these factors (the doubling of bus travel in 15 years and 40% increase in rail travel). The continuing growth in non-commuting rail travel nationally over the last 20 years can also be attributed in part to the greater ease of getting pre-journey and in-journey information as well as the simplification and convenience of ticket purchase.

The capability of satnavs and similar devices, and their ability to reflect actual traffic conditions into their routes, is taking much uncertainty out of car travel and making the journey more tolerable and less stressful.

The current generation of satnav devices enables both the *predictable* variations in traffic conditions and the *unpredictable* variations to be taken account of. Such a device will

- find and show a route using network travel times which (from its constantly updated database) are known to be the expected travel times for that day and time of day

- then read the actual travel time on the route at that moment, picking up any delays, adjusting the estimated journey time accordingly and showing the amount and location of delays. These delays will vary – increasing or decreasing or going away – as the driver moves towards their location. Alternative routes may be shown and offered at appropriate points.

Supporting this capability is the permanent connection of the device to the satnav operator’s system, so that firstly the travel times experienced by that driver are collected and used to update the expected travel times on those route sections at the particular time/day; and secondly current delays are captured from vehicles stuck in them, and communicated to their database and onwards to travellers using that route.

These and similar developments continue to change the relative attractiveness of different modes of travel, both for shorter-distance urban travel (of less interest to us) and for medium- and longer-distance journeys; for non-business journeys this may also influence choices of destination.

Given the ubiquity of these systems over the last 10-15 years it might be tempting to believe that the potential for information and devices like this to influence choices of mode, route and timing of journeys is in a mature phase and has largely played out, whether in urban areas or for longer-distance journeys; but we do not believe this is the case. Conversations with the industry suggest that the next stages of development in this area for vehicles and their drivers may depend on the successful emergence of business models (which don’t currently exist) which provide the right sort of engagement between data providers, communications networks, automotive companies and road infrastructure providers; this may also in time lead to some integration between the different technology streams.

An interesting issue for the MRN and the network operators is whether to leave to the market (for example satnav providers) the provision of information about traffic conditions on the route and advice about the timing and routing of journeys – both under predictable conditions and when unpredicted delays occur – or whether to develop a way of engaging with drivers so that the 'optimal' decisions about traffic routing on the network can be achieved, recognising that these may not be the same as every driver pursuing their own 'optimisation' using the devices they have with them.

The rising power of the customer Digital technology is not only continuing to transform the transport offer, but also turning upside down the relationship between the customer and the infrastructure and service provider. Thanks to the open data policy of enlightened network operators, with countless apps to present this data, as customers we know much of what is going on in rail, buses and on the Strategic Road Network, if not so well on local authority roads – how well the networks and services are being managed to your benefit.

So first of all, this means the customer is ***omniscient*** – we know how well the network is performing and where there are problems. Next, the customer is ***communicating*.** When services are disrupted, operators do their best to let customers know what is going on. But travellers increasingly learn through Twitter and other social media what's going on – they tweet about anything affecting their journey. In the last 12 months, half a million tweets were made by London rail commuters about service problems, according to one of the many intermediaries who harvest, analyse and publish this data, reporting that Greater Anglia services were top of that league table; it's beginning to change the balance of voice and vocal power between the user and the operator.

Third, customers have clearer ***expectations*.** As infrastructure operators and service providers become more customer-focussed, they increasingly explain what service and quality they are aiming to provide. Customers have access to – and indeed generate - the information about how well the service promise is being met. And finally, customers have ***elected representatives*** to whom all this is communicated, and who (rightly) demand that the public providers become more engaged with their customers and respond.

At the same time, technology is transforming how the network operator and service provider talk directly to the customer; and exploiting big data can not only inform and guide the customer in a highly tailored and customer-specific way, but enable the provider to be seen to be looking after the customer. A strongly customer-focussed culture, and strategic exploitation of technology by providers to communication with customers, can help rebalance the rising power and voice of the user. In the long run, there is no hiding place.

Technology and freight demand on the MRN

Technology is revolutionising how retailing works, for example by moving much demand online and leading to the 'omni-channel' approach to meeting customer demand; among other things this is generating increasing volumes of delivery van movements, to some degree replacing personal journeys to shops and retail parks. These developments affect mostly urban traffic and urban road networks; the effects on the upstream parts of the supply chain – from manufacturer or port of import to national or regional distribution centres – are not so evident, and it is this which has more effect on the MRN.

Developing software and changing business processes continues to improve efficiencies in the scheduling and routeing of freight and delivery vehicles and the supply chains sitting behind them; the benefits of this may well be mostly for downstream deliveries which are largely in urban areas and not so manifest on the MRN.

It is evident, nevertheless, light van traffic is growing at a faster rate than any other vehicle type – and across all parts of the road network; the factors driving this can be speculated on, but little is known and urgent research is needed (See Supporting Document 9 - Demand in the longer term)

Continuing developments in the cost-efficiency and service levels of supply chains are putting increased premiums on the reliability and predictability of the performance of transport links – including the upstream parts of the supply chain, whether by road, rail or water. Whether these pressures may also be leading to the geographical reconfiguration of logistics centres in ways which could alter the pattern of demand on the major road network is a question still to address.

‘Mobility as a service’

‘Mobility as a Service’ is a new term for an old idea to which technology brings new potential. That travel does not require the ownership of the means of transport is an idea as old as the hiring of a horse and as widespread as using a bus, taxi or train. What is new is the ability for technology to make the use of available modes of transport rather more simple and seamless (journey planning, booking, payment and realtime information); the real innovation has come in making available on such a basis modes of transport that have historically been owned rather than hired, in particular the private car and the bike.

For cars, technology is enabling new business models which go beyond the conventional and regulated ‘private hire’ or street-hailable taxi, or familiar models of self-drive car rental. These embrace car clubs (offering instant short term, street-side availability of a self-drive car); ‘car-to-go’ offering the same concept on a take here/leave there basis; lift-sharing facilitated by smartphone apps which match journeys; and Uber, a more instant, tailored and lower cost taxi service facilitated by technology.

In disrupting existing transport markets such innovations are bringing about changes in patterns of car ownership and travel which are still not well understood and are difficult to forecast; they have the potential to reduce private car ownership (and therefore residential parking demand) but what is not yet clear is whether they will change the demand for car travel in a way that might increase rather than reduce congestion (unless managed through regulatory or pricing mechanisms).

These impacts are likely to be most significant and visible in large urban areas (where parking is more restricted, a critical mass of demand more likely and public transport alternatives abundant) and for shorter journeys[2]. They may not impact the Major Road Network significantly, except those major roads in the larger urban areas. The same can be said about the potential and impacts of bike-sharing.

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[2] See for example Feasiblity Study for "Mobility as a Service" concept in London , UCL Energy Institute, May 2015

Technology and Networks

There is a steady flood of innovations under the umbrella of *Smart Highways* with wide application – such as reducing lighting energy costs, charging electric vehicles wirelessly, improving safety (especially for vulnerable users), tracking road surface condition and other structural health monitoring to improve efficiency of maintenance. Innovation in the specification and application of materials for road pavement construction and running surfaces is also helping to extend asset life, improve performance (such as tyre noise or weather resilience), and contain asset maintenance costs.

All these have the capability to make the road – and Major Roads in particular - more 'fit for purpose' (see Chapter 5 of the main Study Report) or to reduce costs for the network operator, for the user or for the community at large.

The world of ITS (*Intelligent Transport Systems)* has a particular focus on technology applications to improve and innovate in the management of traffic on networks and providing information to drivers and from vehicles. Tolling, speed and other driver behaviour management; information to assist drivers and to enable network operators to manage flows and optimise capacity; connectivity between vehicles (V2V) and between vehicles and infrastructure (V2I), both for information and for management purposes. These have the capability to make the total 'system' – embracing the road user, the network operator and the road network itself – function more *effectively*, responding more quickly to changes and stimuli and better meeting the objectives and targets set for the different elements of the 'system', and more *efficiently* through reducing the overall costs of the 'system'. And these have application for Major Roads as much as for urban networks.

Along with automotive technologies, ITS applications lie at the heart of the rapid development towards Connected and Autonomous Vehicles (CAVs), covered in Section 7.3 of Chapter 7 in the main Study Report.

Technology and vehicles emissions

The two main areas of concern are i) the emissions of CO_2 from fossil-fuel vehicles, as greenhouse gases which are driving climate change, and ii) emissions of air pollutants, particularly NO_x and particulate matter from diesel engines, which in cities and along some very heavily trafficked road corridors give rise to excessive concentration levels that harm health.

The latter issues, and the ways technology is enabling the reduction of harmful emissions, are discussed in Supporting Document 5 (Air Quality).

For CO_2 emissions, automotive technology developments continue to bring improvements in fuel efficiency of both petrol and diesel engines, which then reduce the emissions of CO_2. It seems that there remains more potential to continue their downward trend for petrol engines than for diesel: this, alongside the concern about the air pollutants emitted by diesel engines (although on a fast improving track due to tighter regulatory requirements), is likely to stabilise and reverse the recent trends in the proportionate growth of diesel cars.

Alongside this are the developments in alternative energy sources for vehicles, both cars/light vans and trucks/buses. For several years the EU and the UK government have been committed to driving the development and growth of what are called Ultra Low Emission Vehicles (ULEVs[3]) - electric vehicles and hybrids (petrol-electric) in various configurations; governments are also backing the longer term development of alternatives such as hydrogen and fuel cells as energy sources for motive power.

The high cost and very low specific energy of batteries (kwh/kg) has inhibited the attractiveness and market penetration of battery electric vehicles with their heavy load of batteries and a typical range of some 100 miles; this compares with petrol-electric hybrids (with smaller battery requirements) which - particularly the Toyota Prius - have been part of the regular car market for well over ten years. While there continue to be improvements in battery technology and a widening of the range of fully electric cars, the big breakthrough in battery technology that will drastically improve the specific energy capability is still awaited. Meanwhile, policies to make battery charging easier and more convenient for users continue to be implemented.

The GB parc of car registrations as a whole has only 0.2% ULEVs[4], but the ULEV proportion of new car registrations is rising fast, with 1.1%[5] in the year to June 2016.

One direct impact in urban areas and in the environment of Major Roads outside cities will be, in time, the drastic reduction in air pollution from traffic.   Apart from this, the direct impact effect of these developments on the Major Road Network is modest; there may be the opportunity for battery charging 'on the go' through inductive charging from a suitably equipped carriageway, but it is too early to say whether this holds any real potential, in the light of possible cost, usefulness or operational logistical constraints.

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[3] Classified as whole electric vehicles or other vehicles with CO_2 emissions of 75 mg/km or less.
[4] *Vehicles and Drivers Statistics Series - Table Veh0130*, Department for Transport, 2016
[5] *Vehicle LIcensing Statistics: Quarter 2 (Apr to Jun) 2016,* Department for Transport, 2016