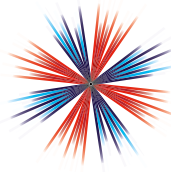ST07

**Department
for Transport**

**INDUSTRIAL
STRATEGY**

Future of Mobility:
Urban Strategy

Moving Britain Ahead

Future of Mobility: Urban Strategy

March 2019

Contents

Foreword

Britain is on the verge of a transport revolution. For much of the past half century, many of the improvements to transport have been gradual and incremental, and focused on increasing the capacity of existing infrastructure to meet growing demand. Yet today, radical new technologies are emerging that within a generation will transform everyday journeys. Zero tailpipe emission cars are replacing those powered by fossil fuels. Self-driving vehicles will soon allow disabled people and older people to enjoy the freedom to travel that the rest of us take for granted. And advances in data will improve the way that transport services are devised, planned and delivered for the passenger.

Such fundamental change in transport within a relatively short period of time and across so many different technologies is unprecedented. The last development in transport to have such profound implications for the country was the advent of affordable motoring in the 1950s, which offered previously unimagined independence to millions of people, and brought massive benefits to our economy. However, it also brought new challenges. There was a decline in public transport use, cycling and walking, and an increase in traffic congestion, greenhouse gas emissions and air pollution.

Life in Britain was reshaped by motor vehicles and mobility was improved for the majority, but not every change was positive.

This time must be different. The best transport technologies of the future will not just make journeys faster, they will also make them safer, easier, more comfortable and more affordable. They will make our towns and cities quieter and less polluted. And they will give us the option to see mobility as a service, integrated and accessible to all.

But the benefits are potentially far greater than just transforming how we travel from A to B – this revolution offers huge industrial opportunities as well. Because of its potential to deliver hundreds of thousands of high quality jobs, increased productivity and new trade deals abroad, we have put the Future of Mobility at the heart of our modern Industrial Strategy. With a long history of transport innovation, a world-class research base and many established technology leaders, the UK is well placed to harness its domestic expertise and to profit from a growing market for cleaner, safer and more efficient transport. We in the Government will support businesses, engineers and academics to use their creativity to solve transport challenges, while remaining mindful of the broader impacts of their innovations. Through intelligent regulation we will also seek to attract the best global transport technology companies of tomorrow to invest and locate in this country.

We have already launched several complementary programmes of work, including the Cycling and Walking Investment Strategy, the Last Mile and Light Rail calls for evidence, and significant measures to improve air quality and decarbonise passenger and freight transport. These are all parts of a single connected approach.

Much of the change in travel will happen first and fastest in urban areas, where transport is busiest, economic opportunities greatest, and space most restricted. Our Future of Mobility programme starts with this urban strategy, which sets out the Principles which will guide our approach to emerging mobility technologies and services. We will be setting out our thinking on the future of rural mobility in due course, to explore how the benefits of transport innovation can be enjoyed by everyone, wherever they live.

We have an extraordinary opportunity here – to put Britain at the heart of the next mobility revolution, and bequeath a better, greener and more successful country for future generations. It's an opportunity that we are determined – with your help – to seize.

Jesse Norman
Minister of State for Transport

1. Executive summary

A moment of opportunity

1.1 Advances in data science, artificial intelligence and sensing technology have increased the speed of transport innovation. Cleaner transport, automation, new business models and new modes of travel promise to transform how people, goods and services move.

1.2 This is the moment to reflect on what we as a society want these changes to deliver and what we want our urban spaces to be like. If successfully channelled, they have the potential to deliver step-change advances for society, the environment and the economy. They could boost productivity and investment, increase export opportunities for UK companies and create high-quality jobs.

Figure 1 Key changes in technology and attitudes bring numerous opportunities to help meet transport objectives
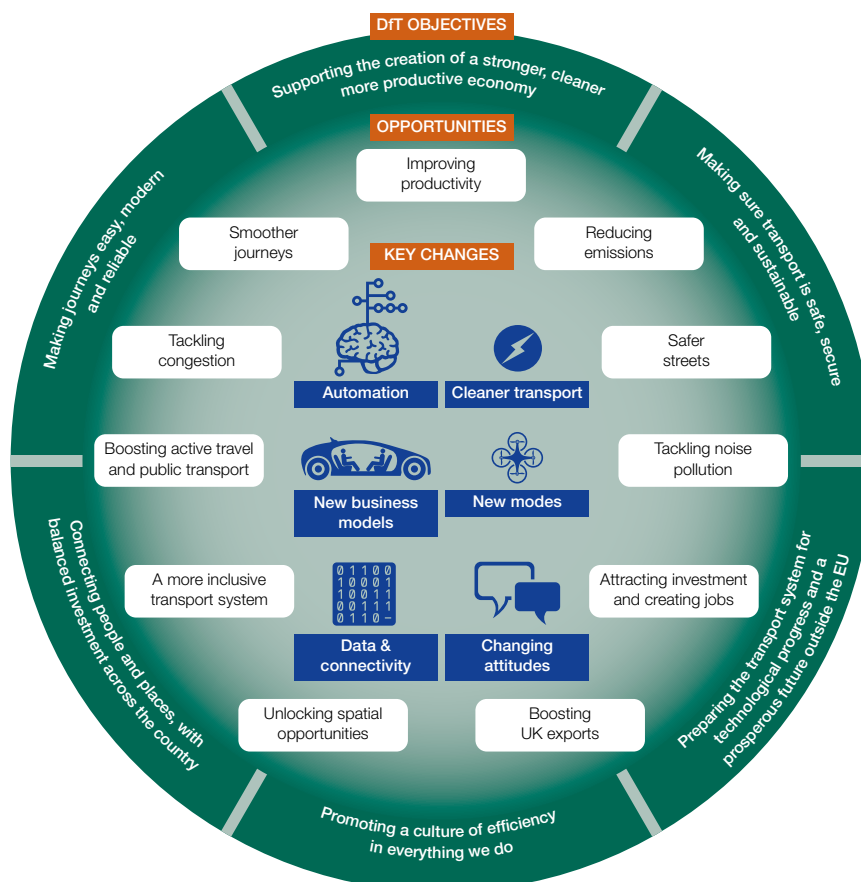
1.3 However, if technological changes are not effectively managed they could have undesired effects, such as increasing congestion or reducing sustainable travel. This is why the Future of Mobility Grand Challenge is a central part of the Government's Industrial Strategy.

A principles-based approach

1.4 This strategy sets out the approach Government will take to seize the opportunities from the changes happening in urban transport. It sets out the benefits we want mobility innovation to deliver and the Principles that will help us achieve these.

In facilitating innovation in urban mobility for freight, passengers and services, the Government's approach will be underpinned as far as possible by the following Principles:

1 New modes of transport and new mobility services must be safe and secure by design.

2 The benefits of innovation in mobility must be available to all parts of the UK and all segments of society.

3 Walking, cycling and active travel must remain the best options for short urban journeys.

4 Mass transit must remain fundamental to an efficient transport system.

5 New mobility services must lead the transition to zero emissions.

6 Mobility innovation must help to reduce congestion through more efficient use of limited road space, for example through sharing rides, increasing occupancy or consolidating freight.

7 The marketplace for mobility must be open to stimulate innovation and give the best deal to consumers.

8 New mobility services must be designed to operate as part of an integrated transport system combining public, private and multiple modes for transport users.

9 Data from new mobility services must be shared where appropriate to improve choice and the operation of the transport system.

1.5 Together, these Principles help to define our vision of urban transport. There may be tension, even potential conflict, between them. That is to be expected, since transport policy always has multiple goals and multiple constraints. But they still present a clear signal of what we are seeking to achieve.

1.6 We want the UK to be a global leader in transport innovation that aligns with these Principles. We will create a fertile environment for innovation and investment, enabled by a flexible, responsive regulatory system, and work with cities to give them the tools to innovate.

Next steps at a glance

1.7 Given significant uncertainty about the rate of technological development and consumer adoption, we do not have all the answers now. Our approach will need to adapt over the coming decades. In 2019, our priorities for the Future of Mobility Grand Challenge are as follows:

Implementing a flexible regulatory framework

Initiating four new areas of focus for our Regulatory Review:

- **Micromobility vehicles, and how to trial them**
- **Mobility as a Service**
- **Transport data**
- **Modernising bus, taxis and private hire vehicles legislation**

These are in addition to existing regulatory programmes for:

- Zero emission vehicles
- Self-driving vehicles
- Drones and future flight
- Maritime autonomy

Source: Sparta Technologies Ltd

Source: UK Autodrive

Supporting industry and local leaders

- **Fostering experimentation and trialling**, through the launch of up to four Future Mobility Zones with £90 million of funding
- **Encouraging the sharing and harnessing of data**, through the creation of standards and platforms that make it easier to access and use transport data
- **Supporting the automotive industry to adapt**, by continuing to fund the research and development of low carbon technologies
- **Building local capability**, through supporting local areas to implement the Principles for shaping the future of urban mobility and develop Local Industrial Strategies
- **Preparing the urban environment**, through publishing guidance to support local decisions about the design and allocation of urban space

Ensuring Government decision-making is robust

- **Building futures thinking into our decision-making**, through updating our strategy and guidance for transport appraisal and modelling
- **Conducting analysis and research**, to build the evidence base for new transport technologies and their impacts
- **Understanding public perceptions**, through public dialogue and surveys exploring attitudes to new transport technologies

Continuing established technology-specific programmes

Capitalising on the opportunities for the UK from developing, manufacturing and deploying specific mobility technologies:

- Zero emission vehicles
- Connected and self-driving vehicles
- Drones and future flight

Definitions

We recognise that some of the definitions of new mobility services are contested. Within this document we use the following definitions.

Active travel: The terms 'active travel' and 'walking and cycling' are used in this document to encompass a range of methods of active mobility, including trips made by wheelchair, mobility scooters, adapted cycles and e-bikes.

Car clubs (sometimes known as car-sharing): Car clubs use electronic systems to provide customers unattended access to cars for short-term rental, often by the hour. Business models can be categorised into round-trips, where the vehicle must be returned to its home station, and flexible, which allows one-way trips. Vehicles may be owned by individuals and lent out on a peer-to-peer basis via an intermediary platform, or form part of a fleet owned by a single organisation.

Demand responsive transport: A flexible service that provides shared transport in response to requests from users specifying desired locations and times of pickup and delivery. Dial-a-ride services scheduled through next day or advance bookings are a traditional example.

Dynamic demand responsive transport: More recent applications of demand responsive transport seek to work dynamically, adjusting routes in real time to accommodate new pickup requests often made minutes in advance.

Fractional ownership: An ownership model that involves a group of people purchasing or leasing a good (such as a vehicle) and splitting the costs.

Micromobility: The use of small mobility devices, designed to carry one or two people, or 'last mile' deliveries. E-scooters and e-bikes are examples.

Mobility as a Service: The integration of various modes of transport along with information and payment functions into a single mobility service. Recent services that allow customers to purchase monthly subscription packages giving them access to public transport and private taxi and bike hire schemes are an example.

Ride-hailing: Ride-hailing services use smartphone apps to connect paying passengers with licensed taxi drivers or private hire vehicle operators who provide rides for profit.

Ride-sharing (sometimes known as car-pooling): Formal or informal sharing of rides between unlicensed drivers and passengers with a common or similar journey route. Ride-sharing platforms charge a fee for bringing together drivers and passengers. Drivers share trip costs with passengers rather than making a profit.

Shared mobility: Transport services and resources that are shared among users, either concurrently or one after another. Public transport, or mass transit, as well as newer models such as car-sharing, bike-sharing and ride-sharing, are all types of shared mobility.

2. Introduction

Technological changes present exciting opportunities to reshape our relationship as individuals and as a society with vehicles, and to address urban challenges. A clear strategic approach will help us seize these opportunities.

The transport revolution of the twentieth century

2.1 The arrival of the motor vehicle revolutionised transport in the twentieth century. The motor car, motor bus and heavy goods vehicles collectively brought about a huge change in mobility for the whole country. Between 1900 and 1950, the number of vehicles on the road rose from almost nothing to nearly five million.[1]

2.2 After 1950, as people became wealthier and cars got cheaper, car ownership and use quickly rose. The private car became by far the dominant mode of transport.

Figure 2 The proportion of kilometres travelled in Britain by car, van or taxi rose from under 30% in 1952 to over 80% by the late 1980s, a proportion that has stayed roughly constant since then[2]

Billion passenger kilometres travelled
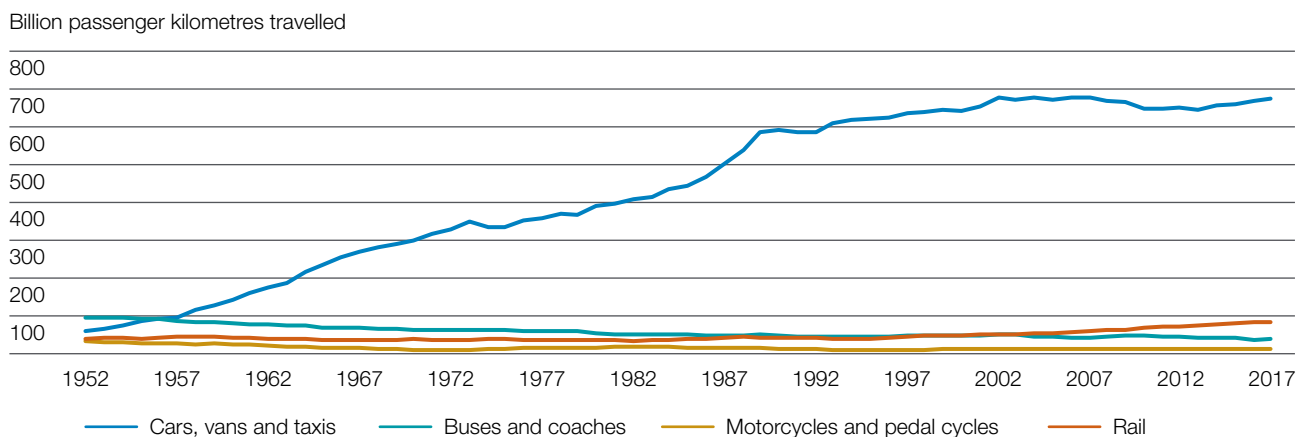
DfT (2018), TSBG0101: Passenger transport by mode from 1952

Towns and cities were increasingly planned to accommodate the motor car as the main means of transport.

Smallbrook Ringway, Birmingham, 1966.

Source: Brewin Books

South Benfleet, Essex,1987

Source: Edward Clack, cc-by-sa/2.0

74% of adults have a driving licence – 80% of men, and 69% of women

76% of households have access to a car, with 35% having two or more

61% of all personal trips are made by car

78% of personal trip mileage is by car

85% of people travel by car at least once a week

2.3 The growth of affordable motoring brought previously unimaginable levels of mobility to huge numbers of people, reshaping society and the economy. People could live and work further apart than was previously possible. Easy travel between cities helped friends and family stay in touch. New activities and opportunities became accessible to millions. Hundreds of thousands of people found employment in industries running, selling and maintaining motor cars.

2.4 The car remains an important part of many people's lives today. Nearly 9 in 10 car users in England (87%) agree that their current lifestyle means they need to own a car, with a similar proportion (94%) saying they enjoy the freedom and independence their car gives them.[3]

The challenges of today

2.5 While the rise of motor transport has brought substantial benefits, high levels of private car ownership and use have also brought serious challenges.

2.6 *Safety:* Despite Britain having some of the safest roads in the world, an estimated 1,793 people were killed on British roads in 2017, with 24,831 seriously injured.[4] Human error was involved in 85% of all road accidents.[5]

Over £20 billion per year

Total social costs of the deaths and health problems resulting from exposure to air pollution, as estimated by the Royal College of Physicians[6]

2.7 *Air pollution:* While air quality has improved since 2010, air pollution remains the top environmental risk to human health in the UK. It is particularly acute in towns and cities, and road transport is a major source, constituting 80% of nitrogen oxides concentrations at the roadside.[7]

2.8 *Congestion:* Time lost as a result of congestion costs the UK economy approximately £2 billion per year.[8] As well as the huge economic costs, congestion also imposes serious environmental costs as internal combustion engine vehicles are less fuel-efficient when driven in stop-start traffic, increasing greenhouse gas emissions and air pollution. These impacts are particularly severe in urban areas; 56% of respondents to the 2017 British Social Attitudes Survey perceive congestion in towns and cities as a serious or very serious problem, compared to 37% for motorway congestion.[9]

2.9 *Greenhouse gas emissions*: Today, transport is the largest greenhouse gas-emitting sector in the UK, accounting for 27% of greenhouse gas emissions. Road transport accounts for 91% of these.

2.10 *Noise pollution:* In England alone, the annual social cost of urban road noise was estimated in 2010 to be £7–£10 billion.[11] This includes the costs of sleep disturbance, annoyance and health impacts from heart attacks, strokes and dementia.

£7.4 billion

Annual burden imposed on the UK economy by lack of physical activity[12]

2.11 *Lack of physical activity:* Reliance on cars contributes to a lack of physical activity, one of the causes of obesity. In 2017, 64% of adults in England were classified as overweight or obese, and the UK currently has the highest obesity levels in Western Europe.[13,14]

2.12 *Inefficient use of limited space:* There are six cars for every ten people in the UK, but the average car is unused 96% of the time.[15,16] According to one report, parking spaces occupy around 15-30% of a typical urban area.[17]

Figure 3 Road transport emissions as a share of UK greenhouse gas emissions from transport[10]
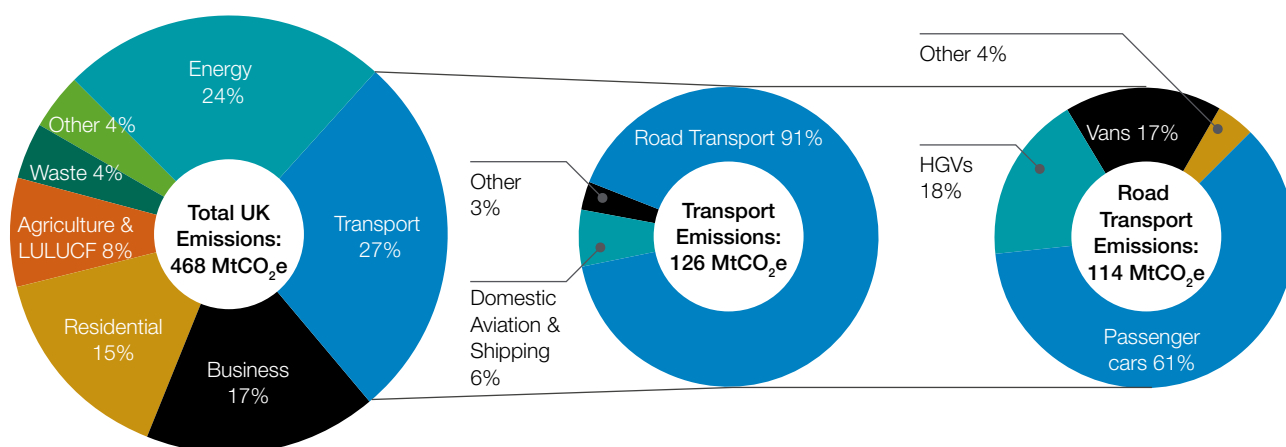
"Other" includes emissions from Public and Industrial Processes sectors

*LULUCF – Land Use, Land Use Change and Forestry

"Other" includes emissions from Rail, Military Aircraft and Shipping, and Aircraft Support Vehicles

Transport emissions do not include International Aviation or International Shipping

"Other" includes Bus, Motorcycle, Other (vehicle engines), Urea Use and LPG emissions

Figures may not add up to 100% due to rounding

Source: BEIS (2018). Final UK greenhouse gas emissions national statistics: 1990-2016

2.13 The number of people living in urban areas in England is forecast to rise by 4.7 million between 2016 and 2041.[18] As cities and towns become increasingly crowded, it will be essential to rethink our relationship with vehicles to avoid exacerbating the challenges of today.

An opportunity to transform travel and the cities we live in

2.14 New types of travel and new business models, enabled by data and connectivity, automation and electrification are starting to transform how people and goods move. This is the moment to reflect on what we want these changes to deliver and what we want our urban spaces to be like. Properly harnessed, new mobility could dramatically influence people's relationship with vehicles and transform our cities.

"For the first time in a century, we have mobility technology that won't just incrementally improve the old system but can completely disrupt it… A total redesign of the surface transportation system with humans and community at the centre."

Jim Hackett, Ford CEO

2.15 A move to connected, automated and zero emission mobility has the potential, if poorly managed, to worsen congestion and public health. But if it is well managed, it could help tackle predominantly urban challenges such as congestion and air pollution, improve connectivity within urban areas, and boost national productivity. It could make city centres greener and quieter, as well as increasing the convenience and affordability of travel, and widening access to mobility for disabled people and older people. Fundamentally, it could allow us to live happier, longer lives.

"A transport revolution in the way people and goods move around will see more changes in the next 10 years than the previous hundred. I'm excited to be working with the Government to help the UK build on its existing strengths and capitalise on that opportunity."

Ian Robertson, Future of Mobility Grand Challenge Business Champion and former board member at BMW

2.16 Industry leaders are recognising the significance of this moment. The UK's Society of Motor Manufacturers and Traders is collaborating with the technology community on its Future Mobility Challenge, looking at how to harness shifts in technology to redefine mobility for millions. Ford has opened a dedicated Smart Mobility Innovation Office in London focusing on future mobility solutions for Europe.

Taking a targeted approach

2.17 Dense urban areas are where we are likely to see some of the greatest opportunities from these changes but they are also where some of the biggest risks lie.

2.18 Many of the trends explored in this strategy will also affect other parts of the country outside urban environments. Work is already under way to consider the impact of technology on our Strategic Road Network and railways spanning the length of the country.[19,20] Our Maritime 2050 Strategy and developing Aviation Strategy will help us harness the opportunities for UK innovators beyond our borders.[21,22]

2.19 Future work will explore the specific challenges and opportunities for rural transport with a Future of Mobility: Rural Strategy. Using our towns and cities as testbeds for innovation, we will trial and improve upon products and services that can be adapted across the country and across the world.

A strategy to put the UK at the forefront of mobility innovation

2.20 This urban mobility strategy is an important part of the wider Future of Mobility Grand Challenge, one of four Grand Challenges established in the Industrial Strategy. Grand Challenges aim to galvanise action by Government, industry and others to take advantage of major global changes to improve people's lives, increase productivity and put the UK at the forefront of the industries of the future.

2.21 The Future of Mobility Grand Challenge aims to capitalise on this period of change in transport and make the UK a world leader in mobility innovation. Achieving this ambition will be linked to and could help facilitate success in the other Grand Challenges. It will help us meet the needs of an Ageing Society, capitalise on UK strengths in Artificial Intelligence and Data and support Clean Growth.

2.22 This strategy is a key step for the Future of Mobility Grand Challenge, setting the direction for future work. It aims to ensure that there is clarity on the scale and impact of the changes that are occurring in mobility and how the Government intends to respond to them to maximise their benefits.

2.23 By outlining the set of Principles that will underpin Government's approach to emerging transport technologies and services, we will help guide innovators and local authorities as they develop, deploy and manage mobility innovation. The development of the Principles has been informed by the Government Office for Science's Future of Mobility Foresight report and the responses to the Future of Mobility call for evidence.[23] We will also use these responses to steer future Government decisions and wider work on the Grand Challenge.

Through a clear and collaborative approach to emerging transport technologies and services, we can enable innovation to flourish and harness this once-in-a-century opportunity to transform mobility for the better.

3. What's changing?

Amid rapid social and economic change, innovations in technology and business models have the potential to transform how people and goods move around our cities.

3.1 Multiple changes in transport technology are happening at once. These are transforming urban transport and creating new opportunities as well as risks. At the same time, significant demographic, economic, and behavioural trends are changing how and why we travel. Together, these technology- and demand-led changes are driving new business models that could have transformative effects of their own.

Changes in transport technology

1. Data and connectivity are transforming journeys

3.2 The increasing availability of data and improved connectivity are allowing travellers to plan multi-stage journeys with confidence and on the go.

3.3 Vehicles capable of communicating with each other and with infrastructure have the potential to provide information to network operators and users in real time to optimise fleet and network management. Estimates suggest there are at least 3 million vehicles with internet connectivity on UK roads, with 50% of new vehicles expected to be connected by 2020.[24]

3.4 Increasing levels of data are also fuelling advances in machine learning, a branch of artificial intelligence allowing systems to learn and improve by identifying patterns in data, without being explicitly programmed. The applications of machine learning to transport include enabling self-driving vehicles, identifying congested areas and more accurately predicting bus times.

Case study: Reducing parking-related congestion

UK company AppyParking is introducing smart parking schemes across several towns and cities, helping to reduce driver stress, congestion and emissions generated while looking for parking spaces by navigating drivers directly to available bays.

AppyParking has worked with a number of UK authorities, including Harrogate Borough Council, North Yorkshire County Council, and

Source: AppyParking

Coventry City Council, to install sensors in Pay and Display parking bays. This means users who download the app can see real-time availability of spaces and eventually EV chargepoints across the cities.

In Harrogate, users no longer need to carry change for a pay and display machine or predict when they will get back to their car. They can start a parking session with a single click, and thanks to sensor technology, their session ends automatically when they drive away. Users pay a small convenience fee for using the service in addition to a per minute fee after the minimum charge has been reached. They are sent a push notification to let them know if they are coming to the end of the maximum stay.

Case study: Improving ambulance response times through artificial intelligence

Liverpool-based design and technology company Red Ninja is using artificial intelligence to create a smart transport system that clears the route for emergency services.

It has developed an intelligent mobility algorithm called LiFE, which changes traffic lights along the vehicle's route based on a combination of real-time and historical traffic data. The LiFE algorithm can shave an average of three minutes off ambulance response times.

The pilot in Liverpool started in 2017 and Red Ninja now have six cities interested in working with them.

2. Transport is becoming increasingly automated

3.5 Improved sensing technology, computing power and software engineering are leading to increasing levels of automation in transport, across many different modes. In the US, self-driving technology company Waymo has accumulated over 10 million self-driven miles, in addition to 7 billion in simulation.[25]

3.6 Total disclosed external investment in self-driving vehicle technology since 2010 stands at over $40 billion, with an almost nine-fold increase in average yearly investment from 2010-2013 to 2014-2018.[26]

£907 billion

Estimated global market for connected and self-driving vehicles in 2035[27]

3.7 UK companies are at the forefront of this field, drawing on our strength in vehicle and software engineering. Several projects will deploy self-driving vehicles on road or public spaces in the UK by 2021.

3.8 These projects are large collaborations between businesses from different sectors and local transport authorities. The Government recently announced three projects to deliver six-month pilots of self-driving passenger services: one bus service in Edinburgh, and two on-demand taxi services in London.[28]

Case study: Self-driving buses across the Forth Bridge

Project CAV Forth, led by Fusion Processing, will bring together organisations from across the UK to develop a high capacity self-driving bus pilot service across the Forth Bridge, a UNESCO World Heritage site. The project will convert five full-size Alexander Dennis single decker manually driven buses into self-driving vehicles.

Operated by Stagecoach, the service will be capable of carrying up to 42 passengers per bus 14 miles between Ferrytoll Park and Ride in Fife and Edinburgh Park Train and Tram interchange. With buses every 20 minutes, this could provide an estimated 10,000 weekly journeys and support the case for rolling out similar services across the UK.

3. Transport is becoming cleaner

3.9 Rapidly falling battery prices, improvements in energy density and electric motors and developments in alternative fuels have the potential to reduce emissions across a range of modes. In the UK we have set a mission to put the UK at the forefront of the design and manufacturing of zero emission vehicles, with all new cars and vans effectively zero emission by 2040.

3.10 Companies, cities and countries worldwide are getting behind the transition to cleaner transport. Over 1 million electric vehicles were sold in China in 2018.[30] According to one forecast, over half of new car sales globally will be electric by 2040.[29]

Selected commitments to cleaner transport

- 26 cities with 140 million citizens will procure only zero emission buses from 2025, and ensure a major area of their city is zero emission by 2030[30]

- Sixteen of the UK's largest van fleets have committed to zero tailpipe emissions from vans in cities by 2028[31]

- Nissan aims to sell 1 million electrified vehicles per year by 2022 and develop eight new pure electric vehicles, building on the success of its new LEAF produced in Sunderland[32]

Figure 4 Electric vehicle battery pack prices fell almost 80% between 2010 and 2017[33]

Battery pack price ($/kWh)

Year	Price
2010	1000
2011	800
2012	642
2013	599
2014	540
2015	350
2016	273
2017	209
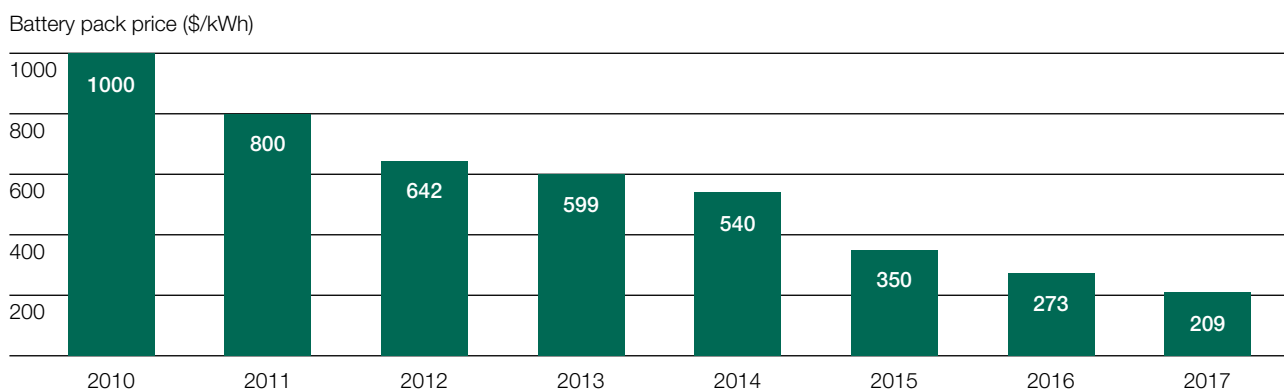
Source: Bloomberg New Energy Finance

3.11 The UK launched the Driving Change Together Partnership in December 2018, in partnership with the Polish Presidency of the United Nations Conference of the Parties on climate change. Building on the Birmingham Declaration signed at the Prime Minister's Zero Emission Vehicle Summit in September 2018, over 40 governments have signed up to the partnership, signalling their commitment to a zero emission future for road transport.

4. New modes are emerging

3.12 Technology is enabling new ways of transporting people and goods. In the air, drones are being used to address local needs, from supporting emergency services to improving the safety of infrastructure inspections. One report estimated that the global market for urban aviation, including commercial drones and vertical take-off and landing (VTOL) services could be worth $1.5 trillion by 2040.[34]

Case study: UK cities pioneering the safe use of drones to address urban needs

In 2018 the Nesta Flying High Challenge concluded its first study working with five cities to investigate where drones could be used to improve public services. As one of the five cities, Southampton identified the possibility of using drones for time-sensitive medical delivery between Southampton General Hospital and other hospitals in the Solent region. This could potentially bypass the existing ferry crossings to provide fast, ad-hoc deliveries of medical samples and supplies on demand. This would save money and time and increase the quality of service offered to patients.

While the study highlighted technical and economic issues to overcome, it has laid important foundations for tackling these challenges going forward.

3.13 On the roads, improved batteries and motors are facilitating the introduction of new forms of micromobility, providing ever more options for the movement of people and goods. These include electric scooters, electrically assisted pedal cycles (e-bikes) and e-cargo bikes. Light electric freight vehicles could carry out 10-15% of delivery vehicle trips in cities, according to one study.[35]

Figure 5 E-bikes sold in Europe reached over 1.6 million in 2016[36]

Units sold ('000)
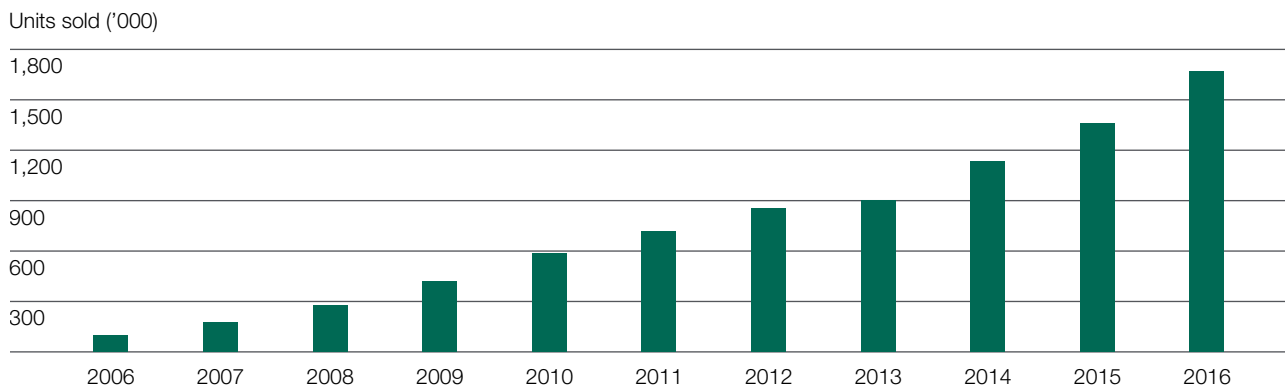
Source: CONEBI (2017), European Bicycle Market

Changes in demand for transport

5. Travel demand is rising overall, but falling at an individual level

3.14 Overall growth in road travel demand across England and Wales is forecast to continue over the coming decades.[37] However, this is largely driven by population growth; people are travelling less per person now than one or two decades ago.

3.15 One of the reasons behind reduced individual travel is a decline in commuting. Between 1995 and 2014, while England's population grew by 11% and employment grew by 18%, commuting journeys fell by 16%. Reasons for this include increases in flexible working, working from home, and part-time and self-employment.[38]

3.16 Shopping trips have decreased 30% over the past decade, coinciding with a rise in online shopping, which now represents almost 17% of total UK retail sales. However, evidence gaps around freight deliveries mean the net impacts of online shopping on traffic are uncertain.[39]

Figure 6 Trips and miles travelled per person per year, England 2002-2017[40]
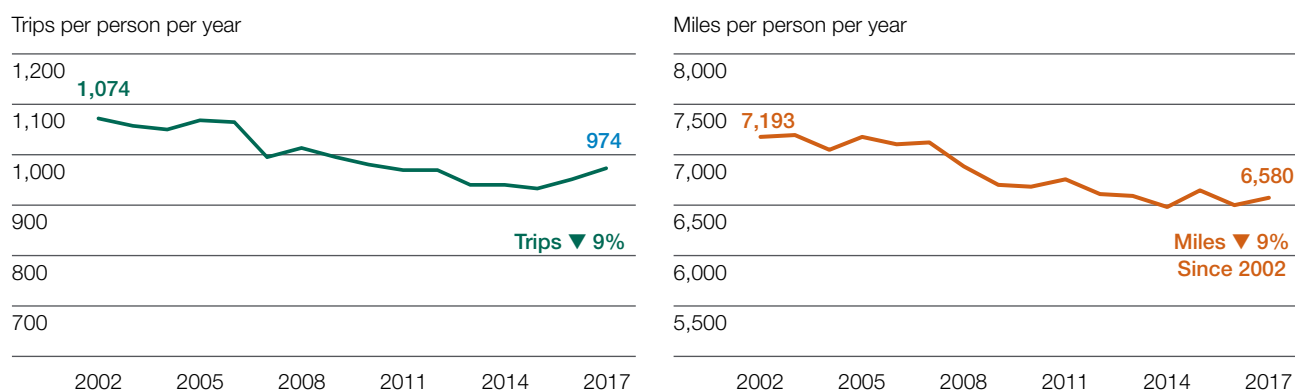
Source: National Travel Survey

6. The population is ageing and travel choices show clear generational differences

3.17 The UK's population structure is expected to change considerably in the coming decades. The 65+ population is projected to grow by around 50% in both urban and rural areas between 2016 and 2039. In comparison, the younger population (aged under 65 years) is only projected to grow by 8% in urban areas, with virtually no increase in the younger population in rural areas.[41]

3.18 These demographic changes matter because of clear generational differences in people's transport choices and needs. For example, younger people are less likely to own cars than previous generations and are driving less, due to factors such as staying in education for longer, moving into long-term employment and starting families later, and the cost of driving.

3.19 However, this is being offset by older people driving more. The average number of miles driven per female aged over 60 per year increased by 66% from 2002 to 2017.[42]

7. Consumer attitudes are changing

3.20 The proportion of 18-75 year olds owning or having access to a smartphone increased from 52% in 2012 to 87% in 2018.[43] Nearly 9 in 10 smartphone users (87%) use their phones for travel purposes, with navigation and route planning being the most popular uses.[44]

3.21 Rising customer expectations are driving passenger transport and delivery services that are increasingly affordable, convenient and personalised. Consumers expect online purchases to arrive promptly, and over 40% are willing to pay extra for same day delivery.[45]

Changes in business models

8. New digitally enabled business models are emerging

3.22 Closely linked to changing consumer attitudes and the harnessing of data and connectivity, we are seeing the emergence of new digitally enabled models of transport provision. These include ride-hailing and Mobility as a Service.

$54.2 billion

External investments into ride-hailing companies between 2014 and September 2018[46]

3.23 The automotive sector is undergoing diversification away from traditional car sales and aftermarket products towards on-demand mobility services, connectivity services and feature upgrades.[47] A 2017 study of 14 major automotive companies found that 12 had launched mobility service offerings either as a pilot or full service, with some announcing partnerships with ride-hailing companies.[48]

9. Shared mobility is becoming more prevalent

3.24 While public transport remains a fundamental form of shared mobility, new models based on shared use or ownership of vehicles are proliferating, enabled by digital platforms and in line with a shift towards a sharing economy in other sectors. Many different models are emerging in the passenger travel market, including new models based on:

3.25 *Sharing journeys:* Passengers travel in the same vehicle at the same time, increasing vehicle occupancy and helping to reduce the number of vehicles on the road. Examples include ride-sharing and dynamic demand responsive transport.

Figure 7 Growth in car club members in the UK between 2007 and 2017

Growth in car club members in the UK

The number of car club members across the UK increased almost eight-fold between 2007 and 2017, to nearly 250,000 members. Whilst around three-quarters of these are in London, there is growth in many parts of the UK.[49] This is evident in Scotland, where there was membership growth of 29% between 2016 and 2017.[50]

32,000   245,000

× 765%

2007   2017
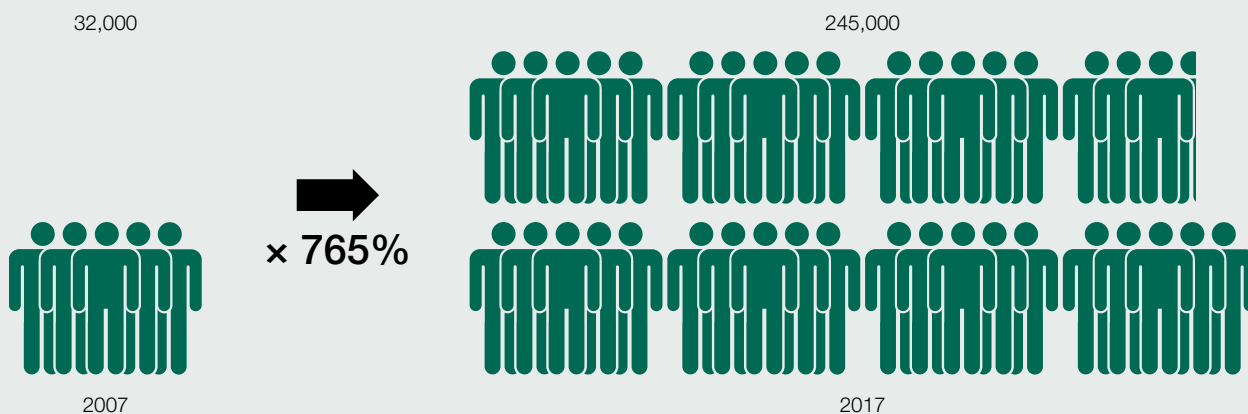
Source: Carplus Annual Survey of Car Clubs

Over 18 million

Quarterly travellers using the world's largest long-distance ride-sharing platform, BlaBlaCar[51]

3.26 *Sharing access:* Users have shared access to vehicles (including cars, bikes and e-scooters) for independent journeys. The vehicles may be owned by individuals and lent out on a peer-to-peer basis via an intermediary platform, or form part of a fleet owned and maintained by companies or transport authorities. Fractional ownership is also an example of sharing access.

3.27 In the freight sector, new models based on sharing have the potential to increase efficiency and reduce empty miles. A Chinese truck-hailing firm connecting truck drivers with shippers raised $1.9 billion in one of the largest private equity funding rounds of 2018.[52]

Vast investments are being made globally in new mobility technologies and business models. Companies are innovating rapidly to unlock new value opportunities and meet demands for cleaner, more convenient travel. Transformative changes in how people and goods move have begun. If successfully channelled, these changes could bring enormous benefits.

4. An opportunity to improve urban mobility dramatically

New technology and business models could deliver substantial benefits for society, the environment and the economy.

Social benefits

Safer streets

4.1 Increasingly advanced driver assistance systems, such as motorway assist, and automated emergency braking systems, are already delivering safety benefits today, using some of the technology that will enable fully self-driving technologies.

4.2 Self-driving vehicles will use sensors, connectivity, and artificial intelligence to understand their surroundings and travel through traffic. They could even learn from their collective experience. Unlike human drivers, automated driving systems will not get distracted or tired, and may be able to react more quickly. For these reasons, connected and self-driving vehicle technologies could help improve road safety, though they will not eliminate road traffic collisions.

4.3 The Government recognises the challenges to the introduction of fully self-driving vehicles. The UK is in a strong position to remain one of the best places in the world to test and develop these new technologies, and to ultimately deploy fully self-driving vehicles in a safe and responsible way.

A more inclusive transport system

4.4 New mobility technologies and services could widen the affordability, availability, and accessibility of transport and narrow existing inequalities in transport provision and use. Lower running costs enabled by automation and the transition away from conventional fuels, along with a more competitive mobility market, offer the prospect of more affordable travel. Combined with greater use of more efficient, on-demand business models, this could enable more frequent and better integrated services in currently poorly connected areas.

4.5 Self-driving vehicles and the increased use of data and mobile applications to assist the planning and execution of journeys should make it easier for disabled people and older people to get around. A recent study found that the cost of running a self-driving ride-sharing service with an on-board steward could be 26-41% cheaper than current 'Dial-a-Ride' services, in addition to offering a more integrated booking platform.[53]

4.6 Innovative technology platforms can also be used to match the supply and demand for transport in rural areas, as well as minimise the risk of digital exclusion among older people and those in more isolated, rural areas with limited digital connectivity. This can help ensure people remain socially connected. In November 2018, Government awarded five tech companies up to £50,000 each to prove the feasibility of their ideas in using cutting-edge technology to tackle the problem of rural isolation and loneliness.[54]

Case study: Supporting people with dementia to get around

Between 2017 and 2018 Betsi Cadwaladr University Health Board in North Wales worked with two small businesses via a Small Business Research Initiative grant to assist people living with dementia who experience high levels of anxiety when travelling to hospital. This project was jointly funded by the Welsh Government and the Department for Transport.

Source: Betsi Cadwaladr University Health Board

The first solution was a unique dementia-friendly transport app developed by Damibu, a health technology company based in Liverpool. The app acts as a companion on a given journey, directing people from their house to the hospital or any other location they are travelling to, and then to the relevant department. Damibu carried out extensive patient engagement in the form of twelve co-creation sessions with potential service users affected by early-stage dementia, and this greatly influenced the design.

In the second project, Oxford-based company Zipabout developed a journey planning and wayfinding platform. By accessing real-time information from across the transport network, the Zipabout platform provides personalised routing to the user to avoid stressful environments such as crowded locations or unstaffed stations. The platform is trialling image recognition technologies to provide ongoing reassurance that a user is in the correct location, boosting the confidence of unsure travellers.

Smoother journeys

4.7 Increased sharing of information in real-time can provide greater clarity on when services will arrive, travel times, comparative costs and greenhouse gas emissions, air quality, step-free access and calories burned. The ability to optimise journey recommendations based on such factors is allowing users to tailor their trips to meet personal needs.

4.8 As well as allowing users to access travel information and plan journeys more easily, Mobility as a Service applications can make it simpler and quicker to book and pay for transport. For example, they can facilitate journeys across different modes on a single ticket or subscription.

Boosting active travel and public transport

4.9 With intelligent design and incentive structures, Mobility as a Service could reduce car ownership and move people towards active and sustainable modes.

Well-managed bike-sharing schemes and e-bikes could widen access to the health and wellbeing benefits offered by cycling; market research has shown that 62% of e-bikes in the UK are sold to people over the age of 55.[55]

4.10 Intelligent use of real-time data and connectivity could make public transport more convenient and responsive. In journey planning tools, the provision of real-time travel times by all modes, including walking and cycling, can help people to make better travel choices.

> With wages currently amounting to around 60% of costs for bus companies, and fuel another 10%, future buses that are automated and electric could halve the current cost of operations. This could transform the commercial dynamics of public transport.
>
> Sir Brian Souter, Stagecoach Group Chief Executive

Case study: On-demand public transport in Liverpool

Following a pilot scheme in Sittingbourne, Kent, ArrivaClick launched its first UK city service in Liverpool in August 2018.

ArrivaClick combines the cost effectiveness of bus travel with the convenience of personalised transit. There are no fixed routes, with journeys determined by where passengers want to go within an area running from Liverpool city centre to John Lennon Airport.

Source: Arriva

Bus company Arriva worked with the city transport authority Merseytravel to roll out the app-based on-demand public transport service, initially with six luxury 15-seat buses but with a view to running 25 vehicles by summer 2019.

Passengers can 'order' and track a vehicle from the app, which provides them with a guaranteed fare and allows them to choose their pick-up point and reserve a seat. Computer algorithms match passengers traveling in the same direction, dynamically routing vehicles in real time to find the optimal route for their trip.

During the pilot in Kent, over half the customers surveyed switched from using private cars to ArrivaClick, with 61% of users using the service a few times a week or more. 43% adopted the service for their daily commute and 9 out of 10 said they would recommend it to a friend.

Environmental benefits

Reducing emissions

4.11 Zero emission vehicles have no greenhouse gas or air pollutant tailpipe emissions. Making the transition to these types of vehicles will help us tackle climate change and improve air quality in urban areas.

4.12 Figure 8 sets out CO_2 road traffic emission forecasts for England and Wales. This shows the impact of our ambition to have almost every car and van zero emission by 2050, compared to the base case of continuing other committed policies.[56]

4.13 If we achieve this ambition, the forecast reduction in CO_2 emissions is 80% by 2050, even against a backdrop of rising GDP and traffic growth. In this scenario, vehicle NOx and PM_{10} emissions for England and Wales are forecast to drop by 95% and 98% respectively.[57]

4.14 Emissions are produced from the manufacture of zero emission vehicles. The Government has assessed greenhouse gas emissions from battery production, which is an energy intensive process. Analysis from a variety of sources consistently shows that battery electric vehicles have substantially lower greenhouse gas emissions over their lifetime than conventional vehicles, even when taking into account the electricity source and electricity used for battery production.[58]

Figure 8 CO$_2$ Road Traffic Emissions for England & Wales (kt)

kt CO$_2$ ('000)

- – – Base ——— Shift to zero emission vehicles
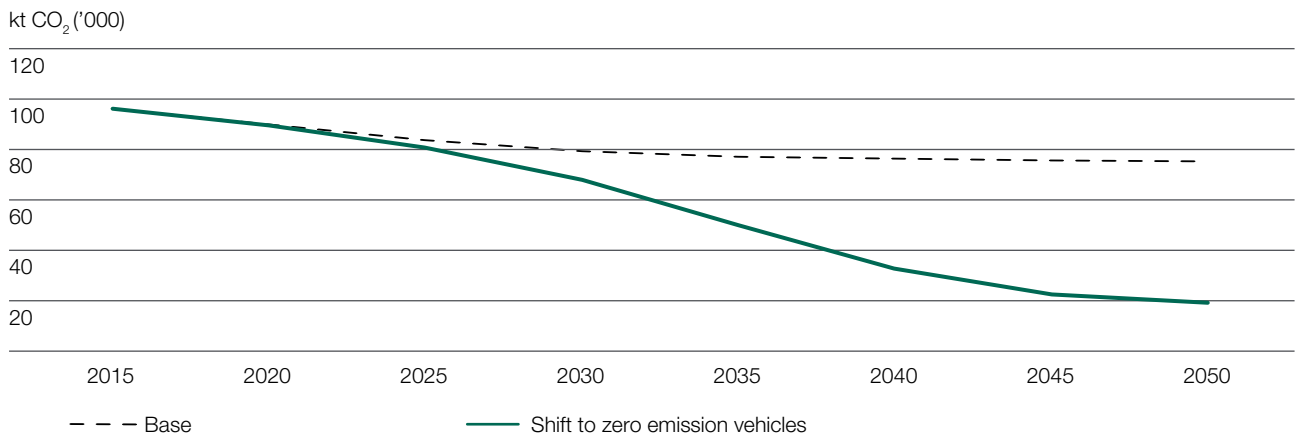
Source: DfT, Road Traffic Forecasts 2018

"What about other types of pollution?"

The Road to Zero strategy has set out a clear pathway to a future with zero tailpipe emissions. As particulate emissions from exhausts have been decreasing, brake wear, tyre wear and road wear have become the largest source of particulate emissions from road transport, and are expected to become increasingly important.

We issued a call for evidence in 2018 to help us understand and quantify the scale of the problem, and are working at international level to develop potential solutions.

Tackling noise pollution

4.15 As well as improving air quality, the transition to zero emission vehicles should cause cities to become quieter, transforming wellbeing for those living close to busy roads and city centres. At the lower speeds typically found in town and city centres, vehicles driven by electric motors are significantly quieter than those powered by conventional engines.

Figure 9 Noise reduction from electric and hybrid vehicles compared to internal combustion engine vehicles[59]

dB

Speed (km/h) —— Hybrid —— Battery electric
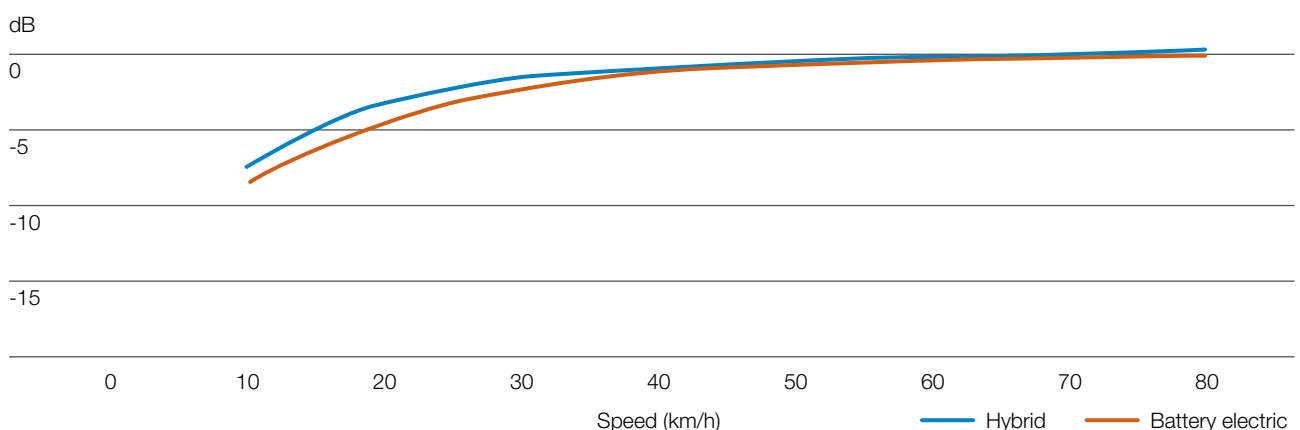
Source: Vejdirektoratet (2013), Noise from electric vehicles

Higher vehicle utilisation rates could enable a reduction in the proportion of space in city centres taken up by cars, improving the urban environment.

Source: WSP and Farrell, Making Better Places.

Unlocking spatial opportunities

4.16 New mobility models could reduce dependency on car ownership, increasing vehicle utilisation rates and allowing urban space to be used more efficiently as parking spaces are removed. This could allow for more green space, with associated benefits including improved physical and mental health and mitigating the higher temperatures and air pollution of urban areas.[60]

4.17 Around 15-30% of land in large cities is currently designated to parking spaces.[61] New mobility models could reduce the need for parking,[62] freeing up land for building new homes or green and open spaces.

Tackling congestion

4.18 Technology is already being used to maximise the capacity of the existing road network. For instance, Split Cycle Offset Optimisation Technique uses data from vehicle detectors and optimises traffic signal settings to reduce vehicle delays and stops. Technology could provide further opportunities in future to tackle congestion, bringing environmental, social and economic benefits through:

4.19 *More efficiently driven vehicles:* Connected and self-driving vehicles could enable smoother driving, reduce accident-induced delays and improve overall network management. It has been estimated that even a low (25%) penetration of connected and self-driving vehicles in urban areas could lead to peak journey time savings of 21% and a reduction in journey time variability of nearly 80%.[63]

Case study: Trialling shared self-driving vehicles in London

StreetWise aims to develop and demonstrate the technology, safety validation methods, insurance and service models for a mobility solution replacing the urban commuter car with shared self-driving vehicles. Trials will start on London roads in 2019.

Part funded by the Government, the project consortium is led by FiveAI, a company specialising in perception and artificial intelligence technologies. Other partners include the University of Oxford, Direct Line Group, McLaren Applied Technologies and Transport for London.

Source: FiveAI

4.20 *Increased sharing:* We know from analysis done as part of road traffic forecasts that transport demand and congestion are very sensitive to assumptions about sharing. Self-driving vehicle and mobility services could, if channelled effectively, increase average car/van occupancy from its current level of 1.55.[64]

4.21 *Increased active travel and public transport:* New technology offers opportunities to shift people towards more space-efficient modes, through widening access to active travel and making public transport more integrated, reliable and attractive. Increased use of car clubs could also help to alleviate congestion; having access to a shared vehicle has been shown to lead to reductions in personal car ownership and miles driven, as well as increased use of other modes of transport.[65]

4.22 *New modes that improve traffic flow:* There is significant potential for new modes of transport to replace traditional vehicle miles in urban areas. This could alleviate congestion, reduce noise and emissions, and improve traffic flow. For example, trials of electric cargo bikes showed that they have the potential to increase road speeds in congested areas as well as reducing emissions, costs and delivery time when compared to van-based last mile delivery services. Drones could also take the place of vans for some types of urban deliveries.

Case study: e-Cargobikes trials

In May 2018 e-Cargobikes.com, with funding from DfT's Innovation Challenge Fund, worked with the supermarket chain Sainsbury's to trial the use of electric cargo bikes to deliver groceries. The e-cargo bikes used have a capacity of up to 480 litres and a payload of 125kg.

A fleet of five zero emission e-cargo bikes was located at the Streatham Common store, delivering up to 100 orders a day to local customers who shopped via the retailer's groceries website.

Source: e-cargobikes.com

The findings from the trial exceeded expectations of potential commercial viability and efficiency. It showed that 96.7% of orders could be fulfilled in a single e-cargo bike drop. It also demonstrated shorter delivery routes and journey times, and increased traffic flow in urban residential areas, due to the ability of e-cargo bikes to make use of cycle and bus lanes, road speeds greater than delivery vans and their narrower size. Finally, it provided evidence of shorter 'doorstep' times, due to the ability of e-cargo bikes to park at or closer to delivery locations.

Economic benefits

Improving productivity

4.23 Improving the flow of people and goods around the country can raise economic productivity and support our Industrial Strategy.

4.24 In addition, fully self-driving vehicles could free up travel time for work or leisure. The average driver in England currently spends 236 hours behind the wheel per year, equivalent to over six working weeks.[66]

4.25 Drones could also free up time for people to focus on higher-value work by automating routine tasks, such as infrastructure inspection, while improving effectiveness and safety and reducing costs.

Source: HSSMI

Attracting investment and creating jobs

4.26 As well as improving efficiency in the transport system and making travel easier, with resulting economic and user benefits, developments in mobility also have the potential to create new commercial opportunities. By fostering an enabling environment for new transport technologies, and building on existing strengths such as zero emission vehicles and artificial intelligence, the UK can attract inward investment and capitalise on these opportunities, generating high-quality jobs in the process.

4.27 As an example of the economic benefits from investment in mobility innovation, analysis by Innovate UK of 77 Low Carbon Vehicle funding projects completed by 2014 estimated that they would have secured total annual sales of £2.9 billion and nearly 12,000 jobs by 2030. The estimated return on every £1 of investment is £8-14 by 2025 and £20-34 by 2030.[67]

£16 billion

PwC estimate of the net cost savings to the UK from the uptake of drones by 2030[68]

Boosting UK exports

4.28 Countries such as the UK that can nurture and retain first-rate talent to solve real transport problems have the potential to embed their solutions into transport systems worldwide. Among the UK's competitive advantages are its world-class universities, strong engineering base, and high concentrations of leading companies in the aerospace and motorsport sectors.[69]

4.29 The UK's mature automotive sector is an example of where we can capitalise on the move towards cleaner, automated transport. By 2035, it is estimated that UK exports of connected and self-driving vehicles will reach £15 billion and there will be a further £0.2 billion of exports of related technologies.[70]

£1.4 trillion

Estimated value of the global market for intelligent mobility by 2030

Case study: UK drone companies tapping into overseas markets

Cyberhawk Innovations is a world-leading visual asset management company, using drones to conduct complex asset inspections and surveys. Its cloud-based software platform converts the data collected into powerful management information. With headquarters in Scotland and offices in Houston, Abu Dhabi and Kuala Lumpur, it operates worldwide in more than 25 countries.

Consortiq helps organisations put drones in the sky safely, with an award-winning training programme and safety management software. It has been contracted by the Canadian Government to support them in developing their regulations for drones.

Altitude Angel creates solutions that enable the safe integration and use of fully autonomous drones in global airspace. Its purpose-built cloud platform enables drone operators, manufacturers and software developers to

Source: Cyberhawk

access real-time airspace, environmental and regulatory data. It has recently become one of the certified providers for the new drone traffic approval service in the USA.

Changes in mobility technology and business models offer huge opportunities to boost the UK economy, reduce the impact of transport on the environment and make travel safer, easier and more inclusive. Yet these benefits are not inevitable. There are also potential risks if mobility innovation is not designed and delivered intelligently and responsibly.

5. The risks from failing to manage change effectively

Failure to shape the implementation of emerging technologies and services could mean that we miss out on the opportunities presented above. Unintended consequences could lead to worse outcomes for society, the environment and the economy.

5.1 Overall, serious risks could materialise if we are too passive in our approach to new mobility technologies and services. These were identified through our Future of Mobility call for evidence and other research, and are outlined below as illustrations of potential outcomes, rather than predictions of likely consequences. Several are relevant to other areas beyond cities and towns. Mitigating these risks is central to our strategic approach, as outlined in Chapter 6.

Social risks

Safety and security threats

5.2 Closer integration of our infrastructure and vehicles with communication networks could lead to increased vulnerability to cyber attacks. As new transport modes and services are introduced, it will be important to consider how they can be safely integrated into the transport system, and vulnerable users can be protected.

5.3 The unprecedented events at Gatwick and Heathrow at the end of 2018 involving drones are examples of new risks being introduced by emerging technology. Measures are in place to deter this type of activity, including the recent expansion of no-fly zones around airports, but future transport systems must be designed with consideration of these emerging threats.

Risks to public transport

5.4 The impacts of new mobility business models and services vary according to how they are designed and implemented.

5.5 Early evidence from the United States suggests that ride-hailing services cause people to use public transport less frequently. One study found that after using ride-hailing, the average net change in public transport use was a 6% reduction among Americans in major cities.[71]

5.6 If public transport passenger numbers are affected by emerging services, this could reduce the ability of public authorities to subsidise marginal services in areas of lower density of demand. This could exacerbate inequalities in access to transport, as lower income groups tend to be most reliant on public transport.

Digital and financial exclusion

5.7 As transport information, booking and payment functions move increasingly onto digital platforms, not everyone will be able to easily access such technology. Only 44% of those aged 75 and over have used the Internet within the last three months, while 1.3 million UK adults have no bank account and are therefore excluded from apps that require bank account registration.[72,73] If alternative methods of accessing transport information and services are not readily available, these groups could become increasingly isolated.

Effects on health and wellbeing

5.8 Loneliness could increase if a worsening in public transport provision or digital and financial exclusion make it harder for some people to access transport.

5.9 More convenient door-to-door transport options that compete with walking and cycling over short distances could reduce the rates of active travel, worsening obesity levels and the associated burden on the NHS.

Privacy risks

5.10 Inadequate anonymisation and protection of transport data could threaten the privacy of users. Fears over loss of privacy could cause users to give false details or withdraw consent for use, leading to missing, inaccurate and/or non-representative data. This could reduce the quality of the service provided.

5.11 Privacy issues stood out as the biggest concern in research by the Department for Transport (DfT) into attitudes towards drones: six in ten (59%) mentioned this unprompted.[74]

Environmental risks

Urban sprawl

5.12 Most studies into the impacts of private self-driving vehicles on people's location choices suggest that passengers will value the cost of travel less highly and be willing to commute over longer distances.[75]

5.13 The negative consequences of sprawled development patterns are well documented. For instance, they increase the costs of providing public services including public transport, which in turn exacerbates reliance on private vehicles. They also increase impacts on the natural environment, which is likely to affect water quality and increase flood risk.[76]

Disrupting the local environment

5.14 New modes and business models could have potentially disruptive impacts on the urban environment. For instance, there are fears that excessive use of drones and other new airborne modes could create noise and crowd the urban skyline.

5.15 Obstructions caused by the illegal parking of dockless bikes have caused concerns in several UK cities.

Increasing congestion

5.16 While there is a lack of data on the impact of ride-hailing services on congestion in the UK, evidence from other parts of the world suggests that these services are increasing vehicle miles travelled in dense urban areas. In San Francisco, a recent study attributed half of the observed congestion growth from 2010-2016 to ride-hailing companies.[77]

5.17 As part of DfT's Road Traffic Forecasts, tests were conducted to investigate how travel demand might change with the deployment of connected and self-driving vehicles. These suggested that in some scenarios traffic could grow significantly.[78] Future levels of demand and congestion will be highly dependent on whether ride-sharing is widely adopted.

Economic risks

Abuse of monopoly power

5.18 There is the potential for the emergence of dominant players in the mobility market. App-based services which link mobility consumers to providers often have powerful 'network effects', meaning that the service gains additional value as more people use it.

5.19 This can cause markets to tend towards monopoly, as new competitors struggle to compete with companies that have large established customer networks and datasets. Organisations that accumulate and withhold a significant share of transport data could limit the ability of local authorities to shape urban transport systems, or force them to pay for the privilege.

5.20 Significant monopoly power could reduce consumer choice, limit innovation and raise the price of mobility. For instance, in a scenario where a dominant mobility firm emerges, data and algorithms could be used to identify and raise prices for individual consumers who have the fewest alternative mobility options. Dominance of a single firm could also lead to a lack of transport provision in the event of that firm abruptly exiting the market.

Loss of jobs and need for new skills

5.21 According to the latest figures, there are almost one million road transport drivers employed across Great Britain.[79] There is an almost 60% probability of this profession being automated, according to the OECD.[80]

5.22 In addition, major trends such as automation, electrification and digitalisation will require the re-skilling of workers across vehicle supply chains, the wider transport sector and related fields, such as electricity generation and distribution.

There is not a binary choice between a future where all the opportunities from the imminent changes in mobility are grasped and one where only the risks materialise. It is plausible, for example, that road safety could improve while congestion worsens. However, the potentially profound nature of some of the changes that are now under way, which could have wide-reaching impacts and affect all parts of society, must not be underestimated. The window of opportunity to shape some of these changes is currently open but will not stay open forever.

6. Our approach to maximising the benefits from the coming revolution in mobility

We need to take a proactive approach towards harnessing the opportunities and mitigating the unintended consequences of profound changes in the way we travel. We must have a clear and well publicised set of Principles to guide Government decision-making, industry and local authorities.

100% of London buses were horse drawn at the beginning of 1901. The last horse drawn bus ran in 1914.[81]

The Strand, London, 1900
Source: © TfL from the London Transport Museum collection

The Strand, London, 1914
Source: © TfL from the London Transport Museum collection

Principles for shaping the future of urban mobility

6.1 Significant changes in mobility could occur relatively quickly. Much of the technology required for new modes, new business models, automation and electrification is available today and is already having an impact on people's mobility choices.

6.2 It is essential that innovators and local decision-makers understand our priorities now; we must not wait for the fully self-driving or flying car. Clearly setting out the Principles that will underpin the Government's approach will help ensure that, as far as possible:

- We can seize the opportunities for society, the environment and the economy, and keep the UK at the forefront of global developments;

- We avoid poor infrastructure and policy decisions and negative unintended consequences, such as the emergence of a monopoly, that could prove difficult to reverse; and

- Local areas are supported to take a coordinated approach to new mobility, facilitating innovation and the flow of goods and people across the country.

6.3 Close collaboration with industry, local authorities and the wider transport community must be at the heart of our approach.

We will support industry to apply these Principles for shaping the future of urban mobility

6.4 We want our clear approach to provide entrepreneurs and companies of all sizes with the certainty they need as they develop, manufacture and deploy new mobility technologies and services.

Where innovation is aligned with the Principles, we will ensure that our business environment supports it to flourish.

We will support local authorities to apply the Principles

6.5 We want cities, towns and city regions to use the Principles to guide their work and decisions, while recognising that the right methods for delivery will depend on local conditions and needs. We will ensure that those willing to lead can become global showcases for mobility innovation that benefits transport users and wider society.

6.6 Together, the Principles below help to define our vision of urban transport. There may be some tension, even potential conflict, between them, reflecting the multiple goals and multiple constraints of transport policy. Yet they still present a clear signal of what we are seeking to achieve.

In facilitating innovation in urban mobility for freight, passengers and services, the Government's approach will be underpinned as far as possible by the following Principles:

1 New modes of transport and new mobility services must be safe and secure by design.

2 The benefits of innovation in mobility must be available to all parts of the UK and all segments of society.

3 Walking, cycling and active travel must remain the best options for short urban journeys.

4 Mass transit must remain fundamental to an efficient transport system.

5 New mobility services must lead the transition to zero emissions.

6 Mobility innovation must help to reduce congestion through more efficient use of limited road space, for example through sharing rides, increasing occupancy or consolidating freight.

7 The marketplace for mobility must be open to stimulate innovation and give the best deal to consumers.

8 New mobility services must be designed to operate as part of an integrated transport system combining public, private and multiple modes for transport users.

9 Data from new mobility services must be shared where appropriate to improve choice and the operation of the transport system.

Principle 1

New modes of transport and new mobility services must be safe and secure by design.

People's safety and security will be our number one priority in our approach to emerging mobility innovation. New vehicles, services and infrastructure should not increase the risk of harm to transport users and other citizens.

We expect new technologies and services to build in safety and security from the beginning and, where appropriate, take steps to guard against emerging cyber threats. As transport data becomes increasingly important to the efficient operation of the network, those involved in handling it must protect personal data for the safety and privacy of individuals.

"Can self-driving vehicles really be safe?"

Before self-driving vehicles are approved for commercial service industry will have to clearly demonstrate to regulators that they are safe. Much of this work is likely to take place in international forums. A recent consultation by the Law Commission on the regulatory framework for self-driving vehicles includes consideration of safety assurance procedures.

It is also essential that any road trials are conducted safely. In 2015, the UK published its world-leading Code of Practice for the safe trialling of self-driving vehicles on public roads. This guidance has recently been updated to include the most up to date thinking on self-driving safety. We are also investing with industry in test facilities to ensure systems are properly road-ready before they are trialled on public roads.

Alongside this the Government has also developed eight principles for good cyber security within the automotive sector.

Case study: Humanising Autonomy

One of the UK companies helping to ensure self-driving vehicles are safe is called Humanising Autonomy. Their technology is able to predict pedestrian intent across multiple cultures and urban contexts, improving interactions between self-driving vehicles and people and ultimately making self-driving vehicles safer.

They are designing their technology with the most vulnerable road users in mind: older people, disabled people, and children.

Source: Humanising Autonomy

Principle 2

The benefits of innovation in mobility must be available to all parts of the UK and all segments of society.

Access to transport is vital to individual freedom and wellbeing, social cohesion and a productive economy. Mobility innovation offers huge opportunities to address disparities in access to travel, tackle loneliness and achieve a more inclusive society.

Government and business must take a conscious decision to consider the needs of all when developing transport policy and transport services. This includes ensuring that new services increase rather than decrease the options available to people in areas with poor public transport links. It means making sure that people without access to the Internet, a smartphone or a bank account still have a good transport offer available to them.

Source: RNIB

Without active engagement and consideration of the needs of an ageing population or those with visible or non-visible disabilities, innovations risk accidently 'designing out' sections of society who might benefit most. New mobility services and technologies should be accessible and inclusive by design, in line with our Inclusive Transport Strategy.[82]

For instance, human operators currently provide assistance to disabled passengers in many forms, and as the driving task becomes increasingly automated, this support function will need to be undertaken by new 'customer assistance' roles delivered by humans or machines. The trend towards ride-sharing will need to cater for users of wheelchairs and mobility scooters, as well as those who, due to certain mental health or developmental conditions, might not feel comfortable sharing with strangers.

Figure 10 % of respondents to DfT's Public Attitudes Tracker Survey that use a smartphone, by age[83]

% of respondents

Age	%
16-24	98
25-34	97
35-44	95
45-54	85
55-64	70
65-74	45
75+	17
All respondents	77
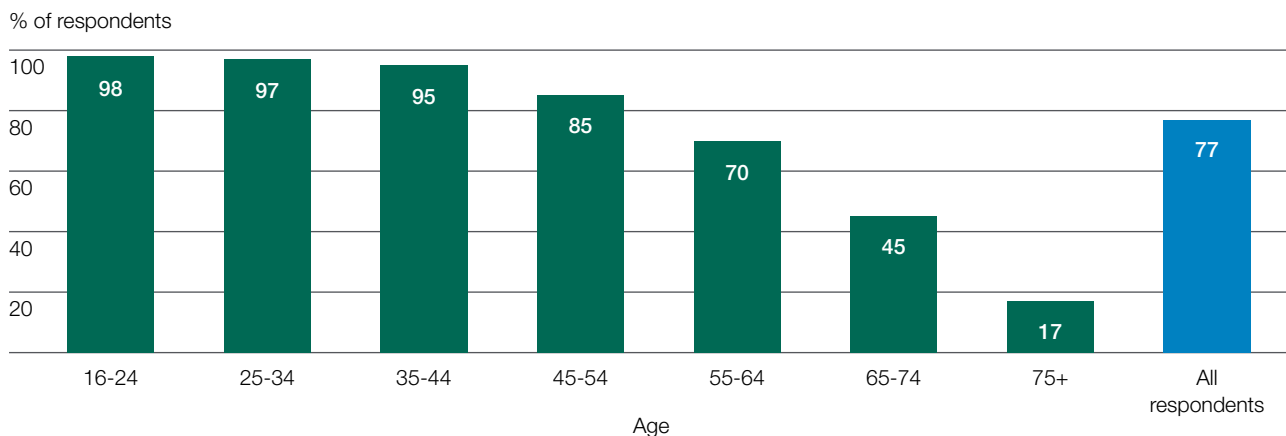
Source: DfT (2018), Transport and Technology Public Attitudes Tracker – Waves 1 and 2

Principle 3

Walking, cycling and active travel must remain the best options for short urban journeys.

The greater the share of journeys taken by walking and cycling in urban areas, the better the air quality and health outcomes and the lower congestion. This will always be true irrespective of technological developments in automation, electrification and new ways of travelling.

In England 45% of all journeys taken by urban residents are under 2 miles.[84] For many people, these trips could be easily undertaken by sustainable, active modes of transport, such as walking and cycling, which support local economies and have huge benefits for health.

New technology and platforms should help make choosing cycling and walking easier, supporting the ambitions and objectives of our Cycling and Walking Investment Strategy. This could be done through, for example, showing routes and timings and always offering these options for short trips, or fully integrating walking and cycling into the options for longer multi-stage journeys.

> *What the studies say: Health benefits of cycling and walking*
>
> - 34,000 incidences of eight life-threatening conditions could be prevented in seven major cities between 2017 and 2040 if cycling increased at rates like those seen since 2000 in London.[85]
>
> - Regular cycling to work is associated with a 45% lower risk of developing cancer and a 46% lower risk of developing heart disease, compared to commuting by car or public transport.[86]
>
> - Those cycling and walking are often exposed to significantly lower levels of air pollution than drivers and passengers inside vehicles travelling along the same urban routes.[87]

Case study: Revolutionary technology enabling more people to experience the benefits of cycling

Father and son Mark and Hugo Palmer of Revolutionworks, a Bristol-based company, have developed a new device which efficiently turns standard pedal cycles into electric bikes. The Revos is a lightweight, low-cost electric-bike conversion kit which is easy to fit and can boost cycle speeds up to 15mph.

Mark and Hugo believe the device will open up cycling to different types of people and help tackle urban congestion.

Source: Revolution Works

We are also supportive of innovation that makes it as easy as possible for a greater proportion of disabled and older people to realise the benefits that active travel can provide.

Principle 4

Mass transit must remain fundamental to an efficient transport system.

Many journeys into and around crowded urban areas, over distances too long to walk and cycle, are always going to be best served by high capacity mass transit.

Irrespective of changes in technology, individual motorised transport will never be able to match high capacity transport for getting people in and around dense urban centres and meeting increased demand on the network.

High Speed 2, for instance, will be the future backbone of our national rail network, delivering better connections between eight out of ten of Britain's largest cities, more than doubling the number of seats available from Euston in peak hours, and carrying over 300,000 people a day.[88]

We want new mobility services to complement rather than compete with mass transit, for example by making it easier to get to and from major transport hubs. We also want public transport operators to consider how new technologies and business models can help them to improve the reliability, responsiveness, accessibility, affordability and safety of their services.

Photographs comparing the amount of road space needed to move 69 people by bus, bicycle and car.
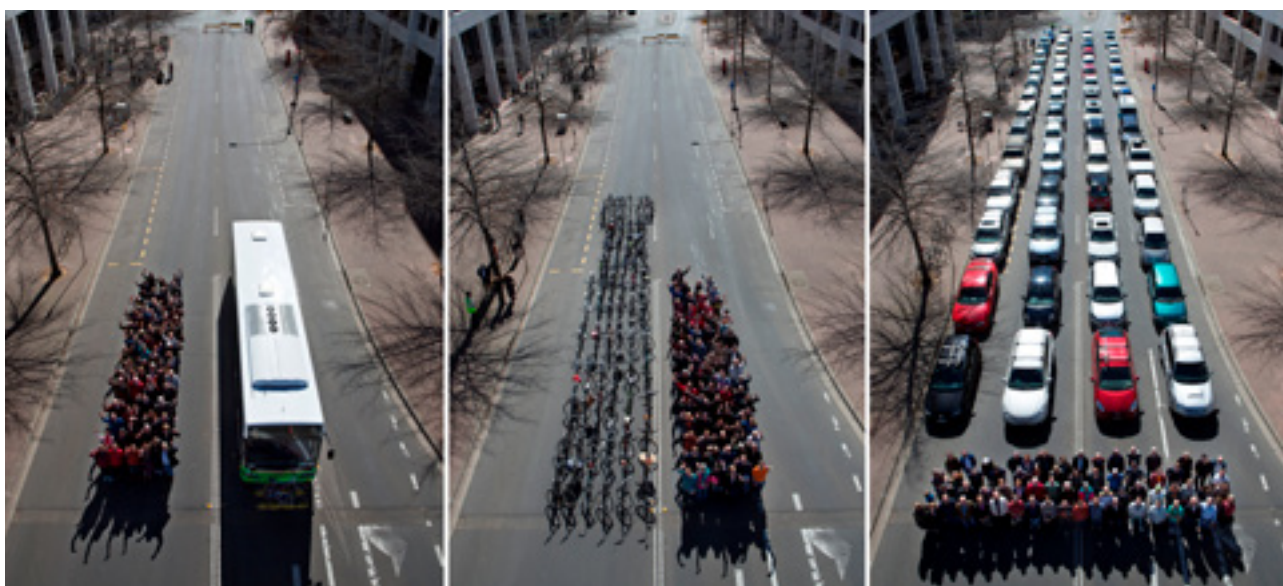
Source: © We Ride Australia.

Case study: Complementing public transport with on-demand minibuses

The Oxford Bus Company is the operator of the largest dynamic demand responsive service in the UK, PickMeUp.

The PickMeUP minibuses, which can comfortably accommodate up to 20 people, serve customers in Oxford's 'Eastern Arc', picking them up from a 'virtual bus stop' within a short walkable distance of where they are. The intelligent software works out the best way to take them and other passengers to their chosen destinations.

To support greener travel and ease congestion, a £2.50 surcharge is added if the trip could be made via an existing Oxford Bus Company bus route without walking over 200 metres.

Principle 5

New mobility services must lead the transition to zero emissions.

The zero emission transition is essential to meeting our climate change targets and improving air quality, particularly in urban areas. The technology already exists to make it happen. New transport modes and business models, such as self-driving vehicles and ride-hailing services, must be in the vanguard of this change, leading it and not holding it back.

We want to see new cars and vans delivering as many zero emission miles as possible as fast as possible. Our ambition is for at least 50%, and as many as 70%, of new car sales to be ultra low emission by 2030, as well as up to 40% of new van sales. This will improve the air we breathe, help ensure we meet our future carbon budgets and build a new market for zero emission vehicle technologies in the UK.

Further details on the Government's support in this transition and how we are working to capture its economic benefits are set out in the Road to Zero strategy, the Automotive Sector Deal and the Government response to our call for evidence on last mile deliveries, published alongside this document.

Case study: Stimulating the zero emission vehicle market through car-sharing

ZipCar is a car club with 250,000 members in London and almost 3000 vehicles of varying sizes. Car-sharing is a fast-growing concept and ZipCar estimates that 800,000 Londoners (15% of those who drive) could be active car club members by 2025.

ZipCar partnered with Volkswagen in 2018 to introduce 325 electric vehicles in to its fleet, and hopes this will help drive investment in London's rapid charging network. The company's vision is for its fleet to be fully electric across all vehicle types by 2025, helping keep Londoners moving while reducing the impact of cars on the urban environment.

Source: Zipcar

Figure 11 Illustrative ultra low emission car uptake trajectory as a percentage of new car sales[89]

ULEV registration as % of all new car registrations   Progress review
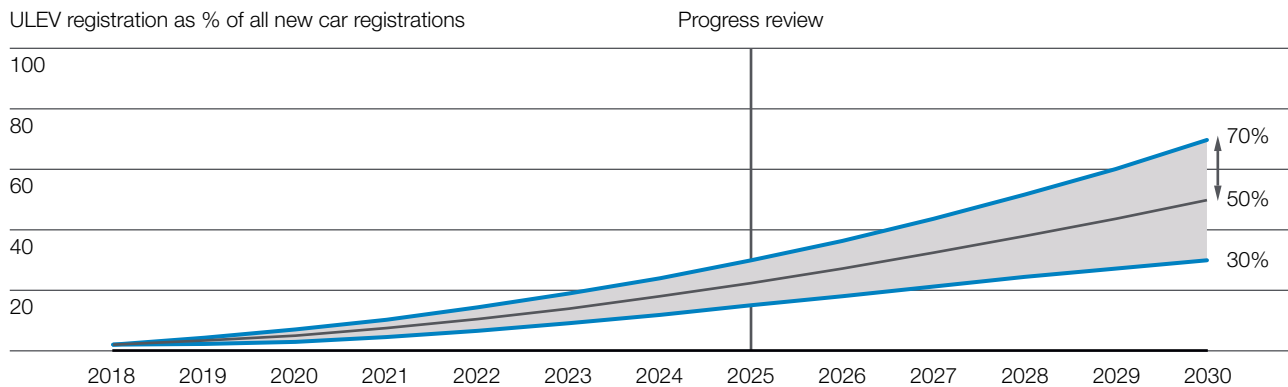
Source: DfT (2018), Road to Zero strategy

Principle 6

Mobility innovation must help to reduce congestion through more efficient use of limited road space, for example through sharing rides, increasing occupancy or consolidating freight.
There is finite road and pavement space in our towns and cities, many of which were laid out long before the advent of motorised transport. The lower running costs enabled by new technologies and business models could worsen congestion if vehicle occupancy and load factors remain low.

As new mobility modes and services are introduced, we want to ensure that they help reduce rather than exacerbate congestion. Exploratory analysis into the effects of self-driving vehicles on road traffic growth has indicated that the effects are highly dependent on how far ride-sharing is adopted.

While the assumptions are subject to uncertainty, the analysis suggested that road traffic could grow 55% between 2015 and 2050 if ride sharing fails to take off and vehicle occupancy decreases from an average of 1.5 to 1.3. This growth in road traffic could increase to 71% if self-driving vehicles also widen access to mobility and allow passengers to use their time in the vehicle more productively. If ride-sharing becomes embedded and average vehicle occupancy increases from 1.5 to 1.7, growth in road traffic during the same period could be 5%.

Innovation that supports the more efficient movement of goods, for instance through the use of consolidation hubs or freight brokerage platforms matching goods and vehicle space, will also be important to reduce congestion.

Figure 12 Results of exploratory analysis into the effect of self-driving vehicles on road traffic growth between 2015 and 2050[90]

71%
Private, productive and mobile

55%
Private travel

5%
Ride-sharing
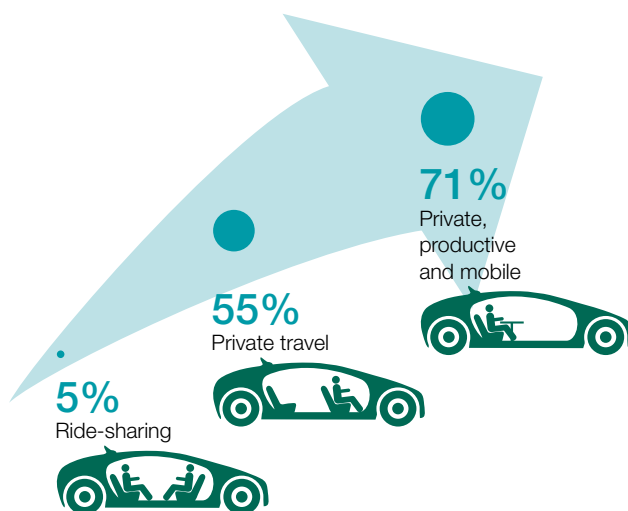
Source: DfT, Road Traffic Forecasts 2018

"Will people really share their rides?"

We recognise that more needs to be done to make ride-sharing an attractive option. DfT's Future Roads research with the public identified a range of social and behavioural barriers to ride-sharing, including concerns about safety, loss of comfort and privacy, and longer and less reliable journey times.

We also understand that for some people, for instance those with mental health or developmental conditions, the idea of sharing a small space with strangers might cause stress or anxiety. How barriers to sharing might be addressed will be one of our priorities for future research.

Source: BlablaCar

Principle 7

The marketplace for mobility must be open, to stimulate innovation and give the best deal to consumers.

A competitive, open marketplace for mobility is needed to increase consumer choice, drive innovation and lower prices.

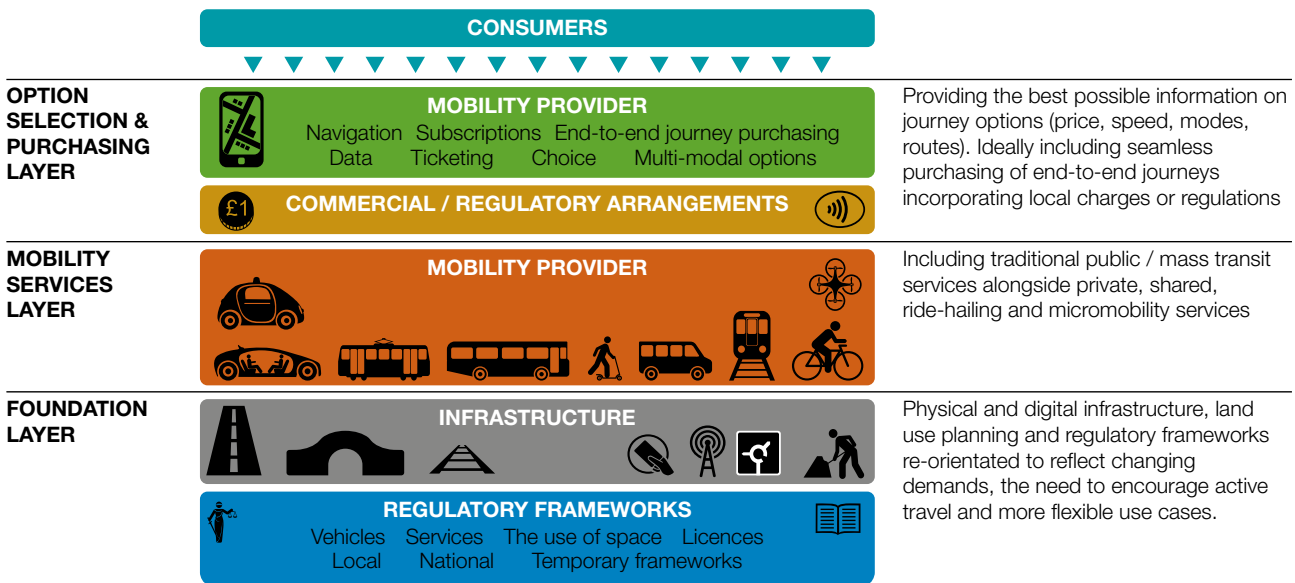Digitally enabled mobility services could make travel easier and more convenient as consumers are able to plan journeys integrated across different modes of transport using travel apps.

However, in order to realise the benefits most fully we need to avoid a fragmented market, or one in which one or two large companies have excessive market power. An outline vision for how a mobility marketplace could operate is illustrated below.

Figure 13 An outline vision for how a future mobility ecosystem could operate

CONSUMERS

OPTION SELECTION & PURCHASING LAYER

MOBILITY PROVIDER
Navigation Subscriptions End-to-end journey purchasing
Data Ticketing Choice Multi-modal options

COMMERCIAL / REGULATORY ARRANGEMENTS

Providing the best possible information on journey options (price, speed, modes, routes). Ideally including seamless purchasing of end-to-end journeys incorporating local charges or regulations

MOBILITY SERVICES LAYER

MOBILITY PROVIDER

Including traditional public / mass transit services alongside private, shared, ride-hailing and micromobility services

FOUNDATION LAYER

INFRASTRUCTURE

Physical and digital infrastructure, land use planning and regulatory frameworks re-orientated to reflect changing demands, the need to encourage active travel and more flexible use cases.

REGULATORY FRAMEWORKS
Vehicles Services The use of space Licences
Local National Temporary frameworks

Threats to the delivery of this vision could emerge in the following circumstances:

- **A dominant marketplace provider emerges.** A single transport platform provider becomes dominant, with most travellers in an urban area accessing transport using their consumer app. This provider then seeks to use its market power to limit the services offered to consumers to those which are most profitable, rather than those which are best for the consumer or the city. Entry to the market for new transport providers becomes tough as the platform provider controls the terms of access.

- **A siloed or fragmented marketplace develops.** Mobility service operators limit access to their services to their own apps. Consumers are never able to access a wide choice for transport options for a given journey and are presented only with a limited number of options, such as only those owned by the platform provider, from any given app or platform.

- **Regulatory or commercial barriers leave the urban transport market fragmented.** A fragmented regulatory environment means the barriers to entry for organisations wishing to integrate transport provision are too high. Transport users continue to have less convenient journeys as they lack the information to plan or buy integrated journeys effectively.

We will seek to mitigate these risks through working to deliver the best possible open marketplace for consumers.
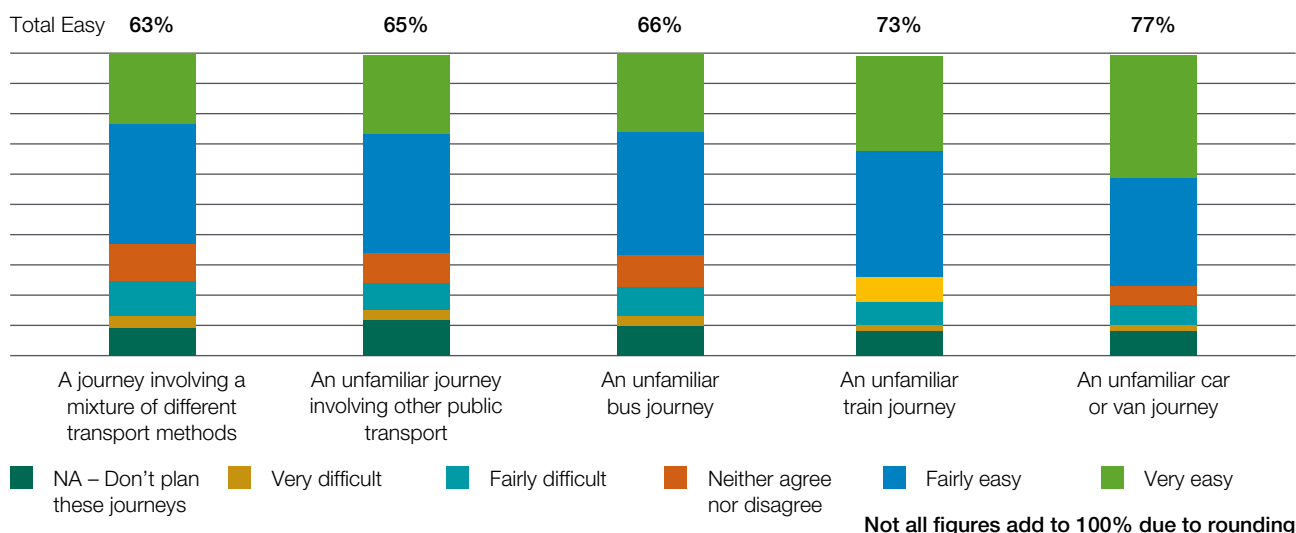
Principle 8

New mobility services must be designed to operate as part of an integrated transport system combining public, private and multiple modes for transport users.

It is often not possible to get where you want to go using a single public transport option. Increased use of data and new technology can help join up different modes, timetables, ticketing and payment across new and existing transport services. This will make it easier to switch between them and improve the user experience.

We recognise the potential of new technology and business models such as Mobility as a Service to make the planning and execution of multimodal journeys easier and shift people away from the private car and towards sustainable transport options. We are keen to support the development and testing of MaaS models in the UK to ensure they align with public policy goals. In so doing, we will also seek to ensure that users do not face unnecessary barriers to accessing convenient travel options every time they enter a new city or town.

Figure 14 Confidence for unfamiliar journey planning is lowest when using a mix of transport methods[91]

| Total Easy | 63% | 65% | 66% | 73% | 77% |

| A journey involving a mixture of different transport methods | An unfamiliar journey involving other public transport | An unfamiliar bus journey | An unfamiliar train journey | An unfamiliar car or van journey |

Legend: NA – Don't plan these journeys | Very difficult | Fairly difficult | Neither agree nor disagree | Fairly easy | Very easy

Not all figures add to 100% due to rounding

Source: DfT (2018), Transport and Technology Public Attitudes Tracker – Waves 1 and 2

Case study: Co-creating MaaS with young people in Scotland

Scotland's first ever MaaS pilot, NaviGoGo, was co-designed by young people, for young people, as part of the Innovate UK funded project, Pick&Mix. The six-month pilot enabled 98 young people in Dundee and North East Fife to successfully plan, book and pay for a range of travel options.

Participants were given access to streamlined and personalised information and payment (where available) for trains, taxis, bike schemes, buses, car clubs and walking, all in one single hub. They also received personalised support for their travel planning and use via social media and contact centre.

Source: Navigogo

Over half (54%) of trial participants agreed or strongly agreed that NaviGoGo made their travel easier. This figure increased to 80% of trial participants indicating their travel would be easier when bus is fully integrated into NaviGoGo. While the commercial case continues to progress, the pilot proved to have driven demand to operators, with respondents reporting an overall increase in use of all modes of transport, including taxi, bus and train.
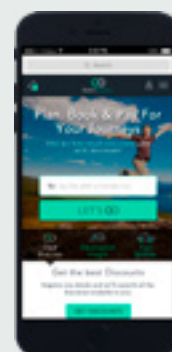
Principle 9

Data from new mobility services must be shared, where appropriate, to improve choice and the operation of the transport system.

Increased data sharing is vital to ensuring an open mobility marketplace, enabling a better user experience and improving the safety and efficiency of the transport network.

Data is a key enabler for innovation in transport and an essential part of 21st century infrastructure.[92] Much progress is already being made in encouraging the rail and bus industries and local authorities to share their data.

However, we know that there are significant gaps. As new privately-run transport services become increasingly important in the

transport system of today and tomorrow, they also need to play their part in sharing data, in a way that maintains individual privacy. This will help to ensure a competitive market, integrate journeys across different modes and improve local authorities' ability to understand and manage the transport network.

Further work will be needed to determine which datasets should be shared and with whom, to strike the right balance between empowering local authorities and consumers and being fair to those who have invested in collecting and formatting data. It will also be important that the sharing and use of data addresses ethical and privacy considerations. The principles in the Data Ethics Framework and the General Data Protection Regulation provide a starting point for this.

Case study: The economic and transport benefits of Transport for London's open data policy

For over ten years, TfL has been releasing a significant amount of data (timetables, service status and disruption information) in an open format for anyone to use.

The provision of this free, accurate and real-time open data by TfL is helping London's economy by up to £130 million a year, according to research commissioned by TfL and conducted by Deloitte. The research quantified the benefits realised through improving journeys, saving people time, supporting innovation and creating jobs.

Source: TfL

More than 650 apps are now being powered specifically using TfL's open data feeds, used by 42% of Londoners. In addition to its own data sources, TfL also receives crowdsourced anonymous traffic data to get an even better understanding of journeys in London to improve its operations.

Citymapper, one of the first journey-planning apps in London, was enabled by TfL's open data. It is now providing its own transport services as a licensed private hire operator. Other businesses which use TfL data to improve customer information include Apple, Google, BusChecker, BusTimes, and Moovit.

The Principles should guide innovators and local authorities as they develop, implement and respond to emerging mobility technologies and business models.

7. Next steps for 2019

We have established a wide-ranging programme of work, with a regulatory review at its core, to enable us to start to realise our ambitions for the Future of Mobility Grand Challenge.

7.1 This chapter presents some of our achievements to date on the Grand Challenge and our plans for 2019 and beyond. Twelve strands of work are set out in four parts:

- Implementing a flexible regulatory framework;

- Supporting industry and local leaders;

- Ensuring Government decision-making is robust; and

- Continuing established programmes for specific technologies.

7.2 These are supplemented by wider enabling measures being delivered across Government. A full summary of the Future of Mobility work programme is on page 52.

In 2018 the Grand Challenge achieved several important milestones

7.3 We have made good progress since the Future of Mobility Grand Challenge was launched in November 2017 (see timeline on opposite page).

Our work in 2019 and beyond will seek to build and expand upon these achievements

7.4 Initiating the Future of Mobility Regulatory Review will form the central part of our work for 2019, alongside a broad programme focused on supporting industry and local leaders, ensuring Government decision-making is robust, and continuing established programmes for specific technologies.

Figure 15 Timeline showing major milestones in 2018

Launch of four research programmes by the Faraday Institution to solve key automotive challenges in energy storage

Announcement of first mission: 'Put the UK at the forefront of the design and manufacturing of zero emission vehicles, with all new cars and vans effectively zero emission by 2040'

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Announcement of winners of the latest round of funding for self-driving vehicle R&D

Zero Emission Vehicle Summit

Announcement of £125m for new aviation technologies and infrastructure

Launch of the Law Commission review into self-driving vehicles

2018

Publication of the Road to Zero Strategy

Announcement of the Future of Mobility Business Champion and Advisory Council

Royal assent for the Automated and Electric Vehicles Act

Launch of the DfT Transport and Technology Public Attitudes Tracker survey

Publication of the Aviation Strategy consultation

Announcement of up to £80m for supporting innovation in electric motor technology

Announcement of £90m at Budget for Future of Mobility Zones to trial new mobility technologies and services

Engaging with business

It is essential that our work on the Future of Mobility Grand Challenge draws on insights from business. To ensure this the Government has appointed a Business Champion and a supporting Advisory Council.

Our Business Champion is Ian Robertson (right), Senior Adviser to the BMW Board of Management. The Advisory Council is made up of:

- Isabel Dedring, Global Transport lead at Arup
- Tracy Westall, Non-executive member of the DfT Board
- Stan Boland, Co-founder and CEO of UK self-driving car company FiveAI

Future of Mobility Grand Challenge: Priorities for 2019

Implementing a flexible regulatory framework	
	• Initiating four new areas of focus for our Regulatory Review: micromobility vehicles; Mobility as a Service; data sharing; and bus, taxi and private hire vehicle legislation
Supporting industry and local leaders	
Fostering experimentation and trialling	• Launching up to four Future Mobility Zones, with £90 million of funding as part of the Transforming Cities Fund
Encouraging the sharing and harnessing of data	• Announcing the winners of a competition to open up local authority parking and traffic management data • Creating several catalogues, standards and platforms to make it easier to access and use transport data • Scoping what additional work and guidance may be required to support data interoperability
Supporting the automotive industry to adapt	• Continuing to deliver the £1 billion Advanced Propulsion Centre and the £246 million Faraday Battery Challenge • Supporting innovation in electric motor technology through up to £80 million for the 'Driving the Electric Revolution' challenge, subject to business case
Building local capability	• Improving our understanding of the needs of local authorities and supporting them to implement our Principles for shaping the future of urban mobility • Continuing to support the development of Local Industrial Strategies in places keen to test and trial new mobility services
Preparing the urban environment	• Publishing guidance to support local decisions about the design and allocation of urban space
Ensuring Government decision-making is robust	
Building futures thinking into our decision-making	• Updating our transport appraisal and modelling strategy to account better for recent and future developments, including in technology • Updating WebTAG with an uncertainty toolkit • Piloting the use of quantitative scenarios in major scheme appraisal
Conducting analysis and research	• Building the evidence base on new transport technologies and services and their impacts
Understanding public perceptions	• Continuing the Transport and Technology Public Attitudes Tracker • Completing a public dialogue exercise focused on connected and self-driving vehicles • Developing a network of third party experts to provide impartial advice to the public on new transport technologies
Technology-specific programmes	
Zero emission vehicles	• Launching the £400 million Charging Infrastructure Investment Fund • Launching a £2 million e-cargo bike grant programme • Consulting on green number plates, smart requirements for electric car charging and changing building regulations so every new home has a chargepoint
Connected and self-driving vehicles	• Working with Meridian, continuing to develop the UK's testbed ecosystem • Working to establish procedures to demonstrate the safety of more advanced trials • Continuing to support a review of the regulatory framework for the safe deployment of automated vehicles in the UK
Drones and future flight	• Starting to deliver the Future Flight programme, which will receive up to £125 million of government match funding, subject to business case • Working to establish how the UK can enable unmanned traffic management and the operation of drones beyond visual line of sight, while keeping the public safe

Wider cross-Government measures (pages 66-67) are not included in this table.

Implementing a flexible regulatory framework

1. Future of Mobility Regulatory Review

7.5 A thriving mobility sector needs an innovative and flexible regulatory framework. That framework must keep people safe and promote active and accessible travel, while providing certainty for investment and the space for invention and trials.

7.6 The UK's regulatory framework for road, rail, aviation and maritime has developed gradually over the centuries, reflecting evolutions in technology and society. Much of the primary legislation underpinning how we regulate taxis and private hire vehicles, for example, dates back to the 1800s. Now, as the pace of change accelerates and the lines between different modes and business models blur, new products and ideas are challenging these existing regulatory structures and scope.

7.7 By undertaking a Future of Mobility Regulatory Review, we plan to address these challenges. It is highly likely that this will necessitate new primary legislation in due course.

7.8 The review will be one of the most significant of its sort for many years. Through a broad programme of work across the modes, from maritime autonomy to micromobility, we will seek to challenge the status quo, asking fundamental questions about how we regulate transport in the UK. These will include questions as to how we define different vehicles, where they can be used, and who has the power to make these decisions at the local, regional, and national level.

7.9 In choosing our initial priorities for the review we have considered areas by their degree of importance and urgency, that is by the scale and proximity of the potential impact if regulatory issues are not addressed.

7.10 DfT is already reviewing regulations in four relevant areas: **zero emission vehicles**, **self-driving vehicles**, **drones and future flight**, and **maritime autonomy.** Alongside this we will initiate reviews in the following areas:

Micromobility vehicles, and how to trial them

7.11 New technologies and trends mean vehicle designs are changing radically, with ever more options for people to choose how they travel. This is particularly true for the micromobility sector, where we are seeing the rapid development of vehicles such as electric scooters and skateboards, low powered last mile delivery solutions and a blurring of previously long established vehicle definitions.

7.12 It is essential that people have the chance to make the most of the opportunities from micromobility, in a way that is safe for both the users of these new vehicles and road users more generally.

Source: Fernhay/UPS

7.13 This review will consider options for appropriate testing regimes for micromobility, to ensure any such vehicles on the road are safe and fit for purpose. As well as identifying basic parameters for safe design and operation of new vehicles such as electric scooters, the aim will be to enable future trials of innovative ideas without the need to change legislation each time. This work may lead to new definitions of vehicles to enable wider use of micromobility.

7.14 This could take the form of locally limited trialling, which will support our aim to enable the leaders of cities and towns to shape emerging mobility technologies and services proactively. The review may also consider measures to enable responsible and effective hire schemes for micromobility, such as a Code of Practice for operators. A consultation on options for enabling micromobility will be issued in due course.

7.15 We will also take the first steps to consider how traffic regulation and street design may need to evolve to accommodate new vehicles and new ways of using roads. This includes undertaking a scoping study to inform an update to the Manual for Streets, and launching a discovery project into how Traffic Regulation Orders and their data can support future forms of mobility and street design.

Mobility as a Service

7.16 Mobility as a Service (MaaS) has the potential to deliver more sustainable transport, improve UK productivity, enhance journey experience and to enable greater social inclusion. By their very nature, MaaS models require seamless integration of multiple modes of transport, which poses intrinsic challenges to the organisation of our regulatory framework.

© Parliamentary Copyright

7.17 MaaS platforms require the interoperability of data from multiple service providers, including timetabling and ticketing and pricing data. In this review, we will examine existing and planned regulatory tools to assist in the opening up of this data specifically to facilitate the socially optimal operation of these platforms.

7.18 We also recognise that new modes and sharing models have the potential to emerge and be integrated within MaaS platforms. We will ensure that as regulation is developed in these areas, it is done so with MaaS in mind.

7.19 In line with the Principles, we will consider how these new mobility services can enable accessible, inclusive and safe mobility services, alongside any potential issues relating to consumer protection.

7.20 We will investigate the case for the Government to do more to shape the way MaaS platforms emerge, to manage unintended consequences, support interoperability across regions, and maintain a fair and open market. We recognise the potential for monopolies to emerge and will review the need for competition regulation.

7.21 Finally, we recognise that legislation and regulation relevant to MaaS is spread across multiple levels of government, in addition to being fragmented across modes. We will work with stakeholders to consider whether the development of guidance would assist those wanting to set up MaaS platforms by clarifying existing regulation in this area.

Transport data

7.22 Opening up and sharing more data is needed to improve choice and the operation of the transport system. For example, in too many cases it can still be disappointingly difficult for cities to obtain good quality, meaningful data from private sector providers.

7.23 This review will consider what role there may be for regulation, or other incentive mechanisms, to support the sharing of transport data in a way that is fair to both innovators and transport authorities, and protects individual privacy. It will consider the extent to which incentive regimes could support healthy competition, empower consumers and support local and national authorities in transport planning.

7.24 We recognise the potential tension between the overall benefits to the transport system of open data practices and the commercial opportunities for companies providing data services. Through this review, we will work to determine which datasets should be shared, and with whom, striking a balance between empowering local authorities and consumers and being fair to those who have invested in collecting and formatting data.

7.25 We will explore how the benefits of data can be shared across the data value chain through new licensing models, so data generators receive value back for sharing data without disincentivising new business models that deliver value to the economy and the travelling public.

7.26 This will also include exploring how local authorities and central government obtain greater value from transport funding, for example through better sharing of data, so that data can help inform future investment decisions and deliver new policy and operational insights.

7.27 Recognising the technical and practical challenges that can deter or prevent data sharing for the public benefit, this review will consider the need for new standards and formats for collating and sharing transport data, as well as new data sharing framework for transport companies. This work will complement projects already under way across Government to address these challenges.

Bus, taxi and private hire vehicle legislation

7.28 Efficient, accessible, and safe shared mobility will form an essential part of our future transport network. Innovative services that sit across the boundaries between buses, taxis, and private hire vehicles are challenging the structure of our regulations.

7.29 This review will build on the significant work already being undertaken to address challenges around these individual services. It will ensure that in aiming to improve bus, taxi and private hire services today, we do not make it more difficult or impossible to achieve the benefits of tomorrow.

7.30 Specifically, we will look at the legislation covering flexible bus services, with a view to ensuring that dynamic demand responsive bus services can operate at the maximum of their potential. This is to address the big question of how we can ensure flexible bus services can be deployed in a variety of geographic environments, and particularly those which are commercially challenging.

7.31 We also know that as self-driving vehicle technologies become more advanced, we will need to consider how unstaffed services might operate without reducing public safety. Building on the work by the Law Commission in their review on self-driving vehicles, we will consider any new measures which may be required to ensure public safety and accessibility in self-driving passenger transport vehicles.

Supporting industry and local leaders

2. Fostering experimentation and trialling

7.32 We will look to create an environment to test new mobility technologies and services and how all users respond to them. This will help to prove the commercial case for investors, identify and respond to any regulatory or other challenges and enable the rollout of successful projects on a larger scale.

7.33 *Priority for 2019:*

- Launching up to four Future Mobility Zones, with £90 million of funding as part of the Transforming Cities Fund. The zones will demonstrate a range of new mobility services, modes and models. They will focus on significantly improving mobility for consumers and providing an exportable template to allow successful initiatives to be replicated in other areas. A competition to select zones has been launched alongside this document.

Case study: Building on local strengths in the West Midlands

The location of the first Future Mobility Zone, in the West Midlands, was announced in 2018 to capitalise on related investments in transport innovation in the region. A plan is currently being developed by Transport for the West Midlands, in collaboration with the DfT, to invest an initial £20 million in a range of future mobility measures.

The West Midlands is also responding to the Future of Mobility Grand Challenge through development of a Local Industrial Strategy, which will build on the area's automotive and rail clusters and major planned investment in new public transport systems and 5G.

3. Encouraging the sharing and harnessing of data

7.34 We will facilitate the sharing and use of transport data. Alongside considering the role of regulation in this, we are driving the creation of standards and platforms that make it easier to access and use transport data.

7.35 *Priorities for 2019:*

- Announcing the winners of a competition to open up local authority parking and traffic management data;

- Commissioning the detailed design of a roads data catalogue, to improve the awareness of existing and emerging data sources;

- Publishing the first national parking data standards;

- Launching the Street Manager Project, a new digital service that will ensure timely publication of data about street works and road works to transform how they are planned, managed and communicated;

- Completing a scoping study into what additional work and guidance may be required to support data interoperability between transport modes and with other systems, such as energy and smart infrastructure.

Case study: Transforming bus services through open data

Following the passing of the Bus Services Act 2017, the Government is introducing regulations requiring bus operators or local authorities to publish information on timetables, routes, fares, tickets, live information and stops from early 2020.

In advance of these regulations being laid, some bus operators are already taking a lead in opening up more data. Reading Buses, for instance, publishes fare data, real-time information on departure and arrival times and vehicle location, and accessibility information.

Using its 'tech lab', it gives partners access to data, facilitating innovation that creates new commercial opportunities and improves customer experience. For example, its partner Routereports developed a tree-strike tool, allowing areas where overgrown trees are striking buses to be reported to the Local Authority. The tool has since been commercialised.

Source: Reading buses

7.38 The strategic transition to low carbon, connected and self-driving vehicles requires the building of new supply chains. The Government, through the Advanced Propulsion Centre, Faraday Battery Challenge and a connected and self-driving vehicles programme (see page 64), is supporting the development of technologies that will form the basis of future low carbon vehicle supply chains and keep the UK at the cutting edge of low carbon automotive innovations.

4. Supporting the automotive industry to adapt

7.36 We will continue the Government's long-standing programme of support to maintain the competitiveness of the UK automotive sector. This includes the Automotive Sector Deal, which sets out a joint strategic vision of how government and industry will work together to respond to the Industrial Strategy Grand Challenges, including the Future of Mobility and Clean Growth.

7.37 The Automotive Sector Deal secures joint investment and long-term commitments to research, develop and commercialise the next generation of low carbon technologies, including world leading battery technologies, and position the UK as the location of choice for the development and deployment of connected and self-driving vehicle technologies.

7.39 For instance, as part of the Faraday Battery Challenge, UK Research and Innovation has invested £80 million in a UK Battery Industrialisation Centre, a new national facility for scaling up and commercialising advanced technologies central to the development and manufacture of batteries. The centre is being established by a consortium of Coventry and Warwickshire Local Enterprise Partnership, Warwick Manufacturing Group and Coventry City Council.

7.40 *Priorities for 2019:*

- Continuing to deliver the 10-year, £1 billion Advanced Propulsion Centre and the £246 million Faraday Battery Challenge;

- Supporting innovation in electric motor technology through up to £80m for the `Driving the Electric Revolution' challenge, subject to business case, covering the power electronics, electric machines and drives.

5. Building local capability

7.41 We will equip local areas to respond to, manage and exploit mobility innovation. Given the significant role of local transport authorities and local highways authorities in local transport provision, regulation and network management, building capability in local areas will be crucial to allowing cities and towns to harness the potential of emerging mobility technologies and mitigate unintended consequences.

7.42 We are already working closely with local areas on many aspects of emerging mobility technology. As an example, DfT has commissioned the Transport Technology Forum to convene local authorities and the technology sector to identify barriers to deploying technology and share good practice for innovation. DfT is also working with the Ministry of Housing, Communities and Local Government on building local capability to use and share data.

7.43 We will continue and expand upon efforts to understand and address the challenges local areas face, strengthening their capacity to prepare for and shape the future of mobility. This will link closely to broader work to support and empower local leaders, through the development of Local Industrial Strategies and the delivery of the Transforming Cities Fund (see page 59).

7.44 *Priorities for 2019:*

- Improving our understanding of the needs of local areas and supporting them to implement the Principles for shaping the future of urban mobility. We will engage closely with the local government sector to consider the steps necessary to address capacity, skills and capability issues identified, and will set these out later in 2019;

- Continuing to support the development of Local Industrial Strategies in places keen to test and trial new mobility services;

- Delivering a series of roadshows for local authorities across the UK to communicate the measures in the Road to Zero strategy and promote best practice approaches to driving the uptake of ultra low emission vehicles. These will include lessons learned through the Go Ultra Low cities programme (see page 63);

- Providing an evaluation framework for local authorities deploying connected vehicles and infrastructure.

National Infrastructure Commission work to support the development of urban transport strategies

In 2018 the National Infrastructure Commission published the UK's first National Infrastructure Assessment, setting out recommendations to the Government on future infrastructure strategy. The assessment highlighted the challenges faced by cities, where congestion and growth mean there is a pressing need for improved transport infrastructure.

Now the Commission is doing further work with cities to help them build the capabilities needed to implement ambitious and effective infrastructure plans. This includes a series of knowledge sharing events for cities to learn from each other and other experts on how to put together successful strategies, resulting in a publicly available source of guidance for city authorities. It also includes work with five case study cities as they develop new infrastructure plans, providing them with access to external challenge and advice.

6. Preparing the urban environment

7.45 We will continue to recognise the two-way relationship between urban space and transport to help ensure that new modes and mobility models lead to improved outcomes. This will involve considering how urban infrastructure may need to adapt in the coming decades, from the better management of a potentially contested kerb space to the creation of landing pads to enable new aerial modes.

7.46 This will build on significant work already under way to upgrade the UK's infrastructure to support more immediate changes in mobility, including measures to support the development of the electric vehicle chargepoint network (see page 62). Infrastructure is one of the five foundations of productivity that the Government is focusing on through the Industrial Strategy.

7.47 DfT will also work closely with the Ministry of Housing, Communities and Local Government to ensure that changes to the planning practice guidance help to meet transport objectives, including through alignment with the Principles for shaping the future of urban mobility.

7.48 *Priority for 2019:*

• Publishing guidance to support local decisions about the design and allocation of urban space. This will be produced in conjunction with the Institute of Transport Studies at Leeds University.

Investing in sustainable travel through the Transforming Cities Fund

The Transforming Cities Fund is a £2.5 billion fund announced as part of Budget 2017. Part of the Industrial Strategy, the Fund aims to make a small number of large, transformative investments to drive up productivity in English cities through improved intra-urban connectivity.

Over £1 billion has been devolved to six Mayoral Combined Authorities, with Greater Manchester allocating £160 million towards its new Bee Network of active travel corridors and junctions to encourage cycling and walking in the city region.

Government has shortlisted 12 city regions to share the remaining £1.28 billion of the Fund and is working with these areas to develop their plans. A Community of Practice will encourage all 18 city regions involved in the Fund to learn from each other and stakeholders.

The cities are also eligible to become Future Mobility Zones, trialling innovative solutions to improve urban mobility. More details on the Future Mobility Zones can be found on page 56.

Source: Greater Manchester Combined Authority/Transport for Greater Manchester

Ensuring Government decision-making is robust

7. Building futures thinking into our decision-making

7.49 We will seek to ensure that decisions about long term transport investments and policies reflect uncertainty about the future and are as resilient as possible to the impacts of emerging technologies, modes and services. The Government is also considering how the tax system will need to adapt to manage these changes.

7.50 *Priorities for 2019:*

- Updating our transport appraisal and modelling strategy to account better for recent and future developments, including in technology. We recently consulted on how to do this and will announce our decisions in 2019;[93]

- Updating WebTAG, the Department for Transport's guidance on transport modelling and appraisal, with an uncertainty toolkit to help transport scheme promoters to take account of future uncertainty in their economic cases;

- Piloting the use of quantitative scenarios in major scheme appraisal, to reflect better the uncertainty associated with technological and other developments. Pilots will complete in summer 2019.

8. Conducting analysis and research

7.51 We will build the evidence base on new transport technologies and services to ensure that our decision-making is robust, our interventions are targeted, and transport is designed to meet the needs of all users.

7.52 *Priorities for 2019:*

- Identifying the effects of wider socio-economic trends on the ways people will use new transport technologies and services;

- Exploring the effects new mobility services may have on vehicle ownership and market structures;

- Understanding the factors that influence the uptake of ride-sharing and vehicle-sharing;

- Understanding the impacts of new modes, business models and technologies on the ownership and sharing of data.

9. Understanding public perceptions

7.53 We will work to understand public attitudes to new transport technology to shape Government decision-making and inform commercial offerings. We will also build public understanding of the benefits and opportunities of new technology and better communicate how the Government is managing public concerns.
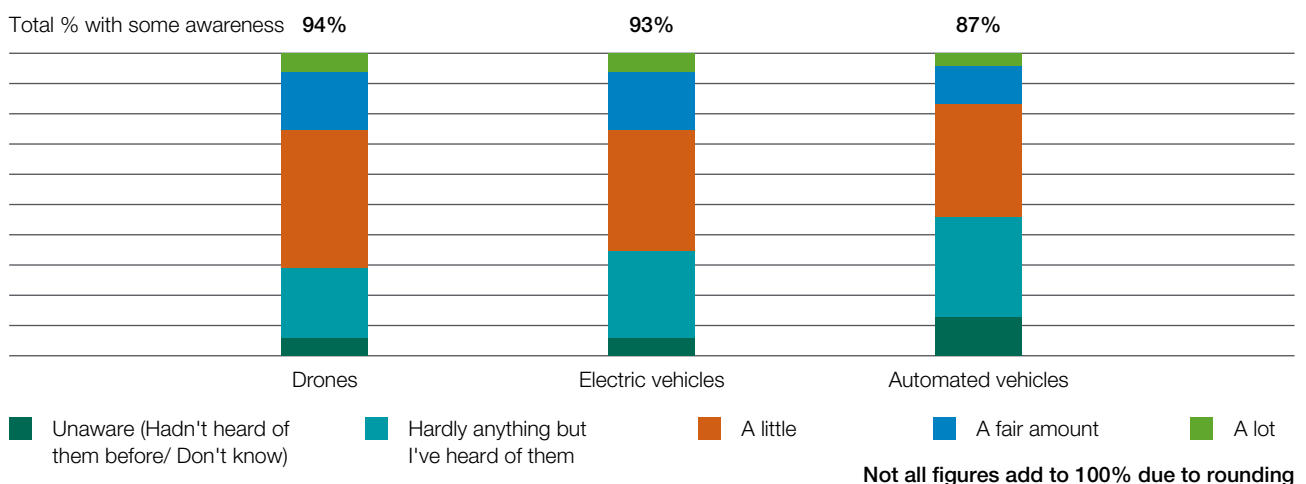
7.54 *Priorities for 2019*:

- Continuing the Transport and Technology Public Attitudes Tracker, which is tracking public attitudes to and awareness of transport technologies;

- Completing a public dialogue exercise focused on connected and self-driving vehicles;

- Developing a network of third-party experts to provide impartial advice to the public on new transport technologies.

"What do the public think about new transport technologies?"

Public awareness and acceptance will be major factors in the adoption of new transport services. While overall awareness of new transport technologies was high in June 2018, depth of knowledge was limited. The large majority of those aware said that they only knew 'a little' or 'hardly anything' about the technology in question.

Research has suggested that the potential benefits of self-driving vehicles are not well understood and shared services hold limited appeal. For example, 49% of respondents to the Transport and Technology Public Attitudes Tracker were unable to name any advantages of self-driving vehicles. 65% of respondents recognised the environmental benefits of electric vehicles; concerns around charging infrastructure (56%) and battery capabilities (41%) were the main disadvantages identified.

Figure 16 'How much, if anything, would you say you know about [drones/electric vehicles/automated vehicles]?'

Total % with some awareness **94%**   **93%**   **87%**

Drones   Electric vehicles   Automated vehicles

■ Unaware (Hadn't heard of them before/ Don't know)   ■ Hardly anything but I've heard of them   ■ A little   ■ A fair amount   ■ A lot

Not all figures add to 100% due to rounding

Source: DfT (2018), Transport and Technology Public Attitudes Tracker – Waves 1 and 2

Continuing established programmes for specific technologies

10. Zero emission vehicles

7.55 We will deliver the Road to Zero strategy, the Government's comprehensive plan to support the move to zero emission vehicles.[94]

7.56 Priorities for 2019:

- Launching the £400 million Charging Infrastructure Investment Fund to catalyse the rollout of public electric vehicle charging infrastructure;

- Starting a range of feasibility studies funded through a £40 million programme to develop innovative, low cost charging solutions for electric vehicle owners and users without off street parking;

- Launching a £2 million e-cargo bike grant programme;

- Consulting on smart requirements for electric car charging and changing building regulations so every new home has a chargepoint;

- Consulting on green number plates to promote awareness and uptake of ultra low emission vehicles.

"How will we manage the extra electricity demand from electric vehicles?"

The Government has given certainty by setting a clear long-term ambition for almost all cars and vans to be zero emission by 2050, so the energy sector can manage the transition.

In the National Grid's highest take-up scenario for electric vehicles, they could increase peak demand by around 8 gigawatts in 2040, an increase of less than 15% on current peak domestic demand.[90] The electricity market is already set up to bring forward investment in generation capacity to meet demand, with the Contracts for Difference scheme supporting investment in low carbon generation.

The Automated and Electric Vehicles Act will make sure that in future people are encouraged to charge their vehicle off-peak, helping to reduce demands on the energy system. We have also launched an Electric Vehicle Energy Taskforce, bringing together the energy and automotive industries to plan for future electric vehicle uptake and ensure the electricity system can meet future demand.

National Grid, as the System Operator, and the network companies are responsible for reinforcing the local network, deploying smart grid technologies and procuring smart, flexible services from third parties. This ensures the network infrastructure can transport the power to where it is needed.

Case study: London Electric Vehicle Company supporting the transition to a zero emission fleet

There are around 285,400 taxis and private hire vehicles operating in England. The transition of this fleet to ultra low emission vehicles is a priority for improving air quality in city centres, where many of these taxis spend most of their working lives.

There is now a new market in purpose built zero emission capable taxis. The Coventry based London EV Company's new range extended electric taxi, the TX, is on the road in several cities around the country with over 1000 in the capital.

LEVC has also announced that it will be working with its parent company, Geely Commercial Vehicles, to develop a range of electric commercial vehicles built in the UK. These vehicles will be on sale in the early 2020s, using the latest EV technology. This approach will ensure that LEVC is well placed to support the rapidly growing demand for zero emission capable vans expected in the coming years.

Source: LEVC

Case study: UK cities becoming global pioneers for Ultra Low Emission Vehicle uptake

The Government's £40 million Go Ultra Low Cities scheme supports a handful of cities with ambitious plans for delivering measures to accelerate the zero emission transition, including rapid-charging hubs, free parking and traffic priority for owners of ultra low emission vehicles (ULEVs).

Milton Keynes, one of the selected cities, opened a new electric vehicle charging hub in 2018. The hub includes eight 50kw rapid charging bays and will add four 350kw high power chargers in spring 2019. The facility will then have the capability to refuel an electric vehicle with 300 miles of power in the same time it takes to fill a tank of petrol or diesel.

Nottingham, another of the Go Ultra Low Cities, was the first city in the UK to trial a bus lane allowing use by ULEVs. This recognised the contribution made by these vehicles to cleaner air, removing them from the main flow of traffic to support their use and ease congestion.

There were initial challenges with some motorists not understanding the purpose of the lane and that ULEVs were allowed in it. The council issued free ULEV stickers for drivers to place on their cars to educate motorists. Over 200 stickers have been issued to date with the lane now experiencing very high compliance.

Source: FuelIncluded.com

11. Connected and self-driving vehicles

7.57 We will continue work to secure the UK's position at the forefront of the safe development, production and use of connected and self-driving vehicles.

7.58 *Priorities for 2019:*

- Continuing to support high profile research and demonstration projects focused on connected and self-driving vehicles;

- Working with Meridian to continue to develop the UK's testbed ecosystem for connected and self-driving vehicles;

- Working to establish procedures to demonstrate the safety of more advanced trials of self-driving vehicles;

- Continuing to support a review of the regulatory framework for the safe deployment of automated vehicles in the UK, led by the Law Commission of England and the Scottish Law Commission. The next phase of the review will concentrate on the use of automated vehicles as part of modern public transport networks and on-demand passenger services

Case study: End-to-end self-driving vehicle journeys between London and Oxford

DRIVEN is an ambitious project that will see a fleet of on-demand, fully self-driving vehicles being deployed in urban areas across London and Oxford.

The project integrates cybersecurity, insurance and data sharing into a single system. DRIVEN's autonomous vehicles perform all safety-critical driving functions and monitor roadway conditions for an entire trip, with zero-passenger occupancy.

DRIVEN is a collaborative effort of Oxbotica, Oxford Robotics Institute, re/insurer AXA XL, Nominet, Telefonica O2 UK, Transport Research Laboratory, the UK Atomic Energy Authority's RACE, Oxfordshire County Council, Cicero Group and Transport for London.

Source: DRIVEN

Case study: A world leading ecosystem for the testing and development of connected and self-driving vehicles in the UK

The Government has committed to investing £100 million, matched by industry, to create a world-leading ecosystem for the testing and development of connected and self-driving vehicles in the UK.

Meridian was launched in September 2017 to coordinate this investment and facilitate collaboration across sectors. As the 'one stop shop' for the UK's connected and self-driving vehicle ecosystem, it is able to connect organisations with the right testing environments and consortia, to take them through advanced development, validation and certification of connected and self-driving vehicle systems.

12. Drones and future flight

Source: ARPAS

7.59 As part of DfT's developing Aviation Strategy and the Aerospace Sector Deal, we are considering the role that new potential air mobility solutions, such as vertical take-off and landing (VTOL) concepts, could play in transforming aerial mobility and improving regional connectivity.

7.60 *Priorities for 2019:*

- Starting to deliver the Future Flight programme, which will receive up to £125 million from the Industrial Strategy Challenge Fund, subject to business case and match funded by industry, to aerospace and other manufacturers to research and engineer new technologies and infrastructure;

- Continuing to take an enabling approach to regulation while keeping the public safe. From November 2019, all drone operators will need to register themselves, and all pilots will be required to take a competence test before being able to fly;

- Working to establish how the UK can best implement policies and systems to enable unmanned traffic management and the operation of drones beyond visual line of sight.

Regulators' Pioneer Fund Winners

Civil Aviation Authority (CAA) – Innovation in Aviation Engagement Capability

A recent successful bid to the Government's Regulators' Pioneer Fund will see the CAA transform the way it engages with innovation in the aviation sector, through three new areas of work:

- An innovation gateway allowing anyone to submit ideas for the aviation sector and get an initial response as to whether it needs regulatory input or approval;

- A regulatory lab setting out a roadmap and developing test cases around issues such as automation and urban air mobility. It will bring together everyone with an interest in the area including other regulators, academia and the public, to develop potential regulatory models and avoid duplication between agencies;

- A "regulatory sandbox" where the CAA can give initial guidance to innovators on the development and potential approval of ideas.

UK Space Agency (UKSA) – The Spaceflight Licensing Digital Gateway

This will ensure that the UK's licensing regime for commercial space operations keeps pace with this innovative sector. The Government is working to develop a 'one stop shop' through which operators will apply for spaceflight licences from both the UKSA and CAA.

Wider enabling measures

7.61 Other work being conducted across Government as part of the Industrial Strategy will play an important part in helping to deliver on the Future of Mobility Grand Challenge.

Investing in digital connectivity

7.62 Fixed and wireless networks that are fit for the future will underpin the Future of Mobility Grand Challenge and the Industrial Strategy as a whole.

7.63 *Priorities for 2019:*

- Testing 5G technologies for validating and deploying connected and self-driving vehicles at the UK's premiere vehicle proving ground at Millbrook;

- Funding other trials into digital technologies that will enable connected and self-driving vehicles, such as the A2/M2 Connected Corridor between London and Dover.

£740 million

Funding reserved through the National Productivity Investment Fund for investment in digital infrastructure by 2020/21

Boosting skills

7.64 The education system will play an important part in addressing skills gaps and preparing the UK workforce for the future of mobility.

7.65 *Priorities for 2019:*

- Continuing to invest the additional £406 million in education and skills announced at Budget 2017. This includes boosting spending on maths, digital and technical education to help address the shortage of science, technology, engineering and maths skills;

- Reforming the technical education system, with apprenticeships and qualifications such as T levels, so that it rivals the best in the world, alongside our outstanding higher education system;

- Building on the legacy of the Government's 'Year of Engineering' campaign, by working together to ensure that efforts across industry support each other to increase the number and diversity of engineers.

48,150

Number of higher level apprenticeships started in England in 2017/18[95]

5,066

Apprenticeships created through the Strategic Transport Apprenticeship Taskforce in its first two years[96]

Supporting workers through technological change

7.66 Advances in technology and wider social trends are affecting the whole economy, not just the transport sector. As part of the Industrial Strategy the Government committed to ensuring that the UK labour market remains successful and competitive and ready to embrace the benefits of these changes, including those brought by new employment models.

7.67 As Matthew Taylor's review of the UK employment framework concluded that, in many ways the British model of flexible labour markets works well. However, as our society benefits from the rise in more flexible and varied ways of working, it is important to prevent the erosion of key protections which employees rely on.

7.68 With the emergence of new technology, increasing automation and a changing world of work, it is also essential that individuals are able to develop transferable skills and to learn new skills throughout their working lives.

7.69 *Priorities for 2019:*

- Working to ensure that employment legislation keeps pace with modern working relationship, as set out in the Good Work Plan;[97]

- Rolling out the initial elements of the new National Retraining Scheme to first users. The scheme aims to drive adult retraining and is funded by a £100 million initial commitment.

The Government is committed to creating the conditions in which mobility innovation can flourish and deliver benefits for society. An extensive and collaborative programme of work, guided by the Principles for shaping the future of urban mobility, will help policymakers, businesses and local leaders harness the opportunities from profound changes in mobility.

Conclusion

Cleaner transport, automation, new business models and new modes of travel promise to transform how people, goods and services move. These changes have already begun.

Source: Deregellera Ltd

If successfully channelled, these changes could bring enormous benefits. They could make transport safer, easier, and more inclusive, while minimising its impacts on the environment. They could boost productivity and investment, increase export opportunities for UK companies and create high-quality jobs.

However, if technological changes are not effectively managed they could have undesired effects, such as increasing congestion or reducing sustainable travel. This is why the Future of Mobility Grand Challenge is a central part of the Government's Industrial Strategy.

The Government is committed to managing this transition to maximise the benefits and mitigate the risks of changes in mobility. The Principles for shaping the future of urban mobility present a clear signal of what we are seeking to achieve and will guide our future decisions. The broad programme of work we have launched, with a regulatory review at its core, will help to realise these Principles and foster mobility innovation that benefits transport users and society.

Source: Transport for London

Our approach will need to adapt over the coming decades. We will need to gather and respond to evidence of the impacts of new mobility technologies and services as they emerge. This strategy is an important step towards shaping the direction of mobility innovation and, starting now, we can seize this extraordinary opportunity to revolutionise mobility in Britain for the public good.

Endnotes

1   C. Buchanan (1963), Traffic in Towns.
2   DfT (2018), TSBG0101: Passenger transport by mode from 1952, https://www.gov.uk/government/statistical-data-sets/tsgb01-modal-comparisons. 2017 statistics are provisional.
3   DfT (2018), Transport and Technology Public Attitudes Tracker – Waves 1 and 2. https://www.gov.uk/government/publications/transport-and-transport-technology-public-attitudes-tracker
4   Adjusted estimates from the Office for National Statistics Methodology Advisory Service analysis accounting for change in severity reporting. More details can be found in: DfT (2018), Reported road casualties in Great Britain: 2017 annual report, https://www.gov.uk/government/statistics/reported-road-casualties-great-britain-annual-report-2017
5   2017 analysis of contributory factor information from the road accident data reported to the police (Stats19). Contributory factor data at: https://www.gov.uk/government/statistical-data-sets/ras50-contributory-factors Human error was defined based on contributory factors relating to injudicious action, driver/rider error or reaction, impairment or distraction, behaviour or inexperience and vision affected by vehicle blind spot.
6   https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution
7   Roadside concentrations from the UK plan for tackling roadside NO2 concentrations. See: https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017.
8   https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/382808/dft-ris-overview.pdf
9   2017 British Social Attitudes survey (National Centre for Social Research), https://www.gov.uk/government/statistical-data-sets/att03-attitudes-and-behaviour-towards-roads-and-road-travel#congestion-car-driving-and-the-environment
10 BEIS (2018). Final UK greenhouse gas emissions national statistics: 1990-2016 (online). See: https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2016. These figures do not include international aviation or shipping.
11 https://www.gov.uk/guidance/noise-pollution-economic-analysis
12 P. Scarborough et al. (2011), The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the UK: an update to 2006–07 NHS costs. https://www.ncbi.nlm.nih.gov/pubmed/21562029

13   Health Survey for England 2017, https://files.digital.nhs.uk/5B/B1297D/HSE%20 report%20summary.pdf

14   Health at a Glance 2017: OECD Indicators, OECD Publishing, Paris, https://doi. org/10.1787/health_glance-2017-en.

15   https://www.racfoundation.org/wp-content/uploads/2017/11/spaced_out-bates_ leibling-jul12.pdf

16   Uses ONS data on projected UK population for mid-2017 and DfT's licensing statistics for Q3 2017, https://www.ons.gov.uk/peoplepopulationandcommunity/ populationandmigration/populationprojections/#datasets/ tablea11principalprojectionuksummary and https://www.gov.uk/government/uploads/ system/uploads/attachment_data/file/666905/Vehicle-Stats-Release-2017-Q3.pdf

17   http://www.wsp-pb.com/Globaln/UK/WSPPB-Farrells-AV-whitepaper.pdf

18   Office for National Statistics (2018), Subnational population projections for England: 2016-based. https://www.ons.gov.uk/peoplepopulationandcommunity/ populationandmigration/populationprojections/bulletins/subnationalpopulationprojection sforengland/2016based#main-points

19   DfT (2018), Technology and RIS2, https://www.gov.uk/government/publications/ technology-and-ris2.

20   DfT and BEIS (2018), Rail Sector Deal, https://www.gov.uk/government/publications/ rail-sector-deal/rail-sector-deal

21   DfT (2019), Maritime 2050, https://www.gov.uk/government/publications/maritime- 2050-navigating-the-future.

22   DfT (2018), Aviation strategy, https://www.gov.uk/government/collections/aviation- strategy

23   Government Office for Science (2019), Future of Mobility Foresight report, https://www. gov.uk/government/publications/future-of-mobility

24   https://www.ttf.uk.net/wp-content/uploads/2018/03/Connected-VP.pdf

25   Waymo (accessed 04/02/2019), https://waymo.com/tech/

26   McKinsey & Company, Startup and Investment Landscape Analytics (SILA). Figures do not include internal Research and Development. 2018 figures are until September 2018. Investment figure for self-driving vehicle technology include figures for investments in AV Sensors & ADAS components and AV software & mapping

27   Transport Systems Catapult for the Centre for Connected and Autonomous Vehicles (2017), https://www.gov.uk/government/publications/connected-and-autonomous- vehicles-market-forcecast

28   https://www.gov.uk/government/news/from-science-fiction-to-reality-people-in-london- and-edinburgh-set-to-be-the-first-to-trial-self-driving-vehicle-services

29   Bloomberg New Energy Finance (2018). Electric Vehicle Outlook 2018 (online). Available at: https://about.bnef.com/electric-vehicle-outlook/.

30   China Association of Automobile Manufacturers, cited in Quartz (12 December 2018), "As the world's largest auto market sputters, electric vehicles show no signs of slowing".

31   https://www.c40.org/other/fossil-fuel-free-streets-declaration

32   https://www.globalactionplan.org.uk/clean-air/clean-van-commitment

33   https://about.bnef.com/electric-vehicle-outlook/

34   Morgan Stanley report on urban aviation, cited in Transport Up (10 December 2018), "Morgan Stanley Predicts $1.5 Trillion market for Urban Aviation by 2040": https:// transportup.com/headlines-breaking-news/infrastructure/morgan-stanley-predicts-1-5- trillion-market-for-urban-aviation-by-2040/

35   Ploos van Amstel, Walther & Balm, Susanne & Warmerdam, Jos & Boerema, Martin & Altenburg, Martijn & Rieck, Frank & Peters, Toin. (2018). Urban Technology Research Programme LEFV-Logic: Research on Light Electric Freight Vehicles

36   European Bicycle Market: 2017, CONEBI (Confederation of the European Bicycle Industry).

37   DfT (2018), Road Traffic Forecasts 2018, https://www.gov.uk/government/publications/road-traffic-forecasts-2018

38   https://www.gov.uk/government/publications/commuting-trends-in-england-1988-to-2015

39   http://www.demand.ac.uk/wp-content/uploads/2018/04/FutureTravel_report_final.pdf

40   National Travel Survey

41   https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/ageing/articles/livinglongerhowourpopulationischangingandwhyitmatters/2018-08-13

42   https://www.gov.uk/government/statistics/national-travel-survey-2017

43   https://www2.deloitte.com/uk/en/pages/technology-media-and-telecommunications/articles/mobile-consumer-survey.html

44   DfT (2018), Transport and Technology Public Attitudes Tracker - Waves 1 and 2. https://www.gov.uk/government/publications/transport-and-transport-technology-public-attitudes-tracker

45   DfT (2018), Transport and Technology Public Attitudes Tracker - Waves 1 and 2. https://www.gov.uk/government/publications/transport-and-transport-technology-public-attitudes-tracker

46   McKinsey & Company, Startup and Investment Landscape Analytics (SILA). Figures do not include internal Research and Development.

47   McKinsey & Company (2016), Automotive revolution –perspective towards 2030.'

48   Frost & Sullivan (2017), Top Automotive OEM Mobility Strategies Include Integrating Services on a Single Platform: https://ww2.frost.com/news/press-releases/top-automotive-oem-mobility-strategies-include-integrating-services-single-platform/

49   Steer Davies Gleave for Carplus (2018), Summary: Carplus Annual Survey of Car Clubs in London 2016-17, https://como.org.uk/shared-mobility/shared-cars/Why/

50   Steer Davies Gleave for Carplus (2018), Carplus Annual Survey of Car Clubs, Scotland 2017/18, https://como.org.uk/shared-mobility/shared-cars/Why/

51   BlaBlaCar (accessed 04/02/2019), https://blog.blablacar.com/about-us

52   Reuters (24 April 2018), Softbank, Google join $1.9 billion investment in China truck-hailing firm, https://www.reuters.com/article/us-china-truck/softbank-google-join-1-9-billion-investment-in-china-truck-hailing-firm-idUSKBN1HV0ON

53   MERGE Greenwich, Will AV ride-sharing make cities greener, more efficient and more accessible?, https://mergegreenwich.com/2018/07/16/will-av-ride-sharing-make-cities-greener-efficient-accessible/

54   Cabinet Office (2018), Government uses innovative tech companies to tackle rural isolation and loneliness, https://www.gov.uk/government/news/government-uses-innovative-tech-companies-to-tackle-rural-isolation-and-loneliness

55   Halfords (1 October 2018), Hello 'Silver Cyclist', http://www.halfordscompany.com/news/product-news-from-halfords/hello-silver-cyclist/

56   The 'Shift to ZEVs' curve assumes approximately 97% of the car and Light Goods Vehicle fleet will be powered by electricity by 2050. The forecasts do not assume that Heavy Goods Vehicle and bus fleets move to zero emission technologies, and therefore greater emission reductions than modelled here could be realised in road transport.

57   DfT (2018), Road Traffic Forecasts 2018, https://www.gov.uk/government/publications/road-traffic-forecasts-2018

58   Hodges, J. (2019),, Electric Cars Are Cleaner Even When Powered by Coal, https://www.bloomberg.com/news/articles/2019-01-15/electric-cars-seen-getting-cleaner-even-where-grids-rely-on-coal

59   For relative noise of different vehicles, see: Vejdirektoratet (2013), Noise from electric vehicles, http://www.vejdirektoratet.dk/DA/viden_og_data/publikationer/Lists/Publikationer/Attachments/853/niose-from-electric-vehicles.pdf. For average urban speeds in England, see: DfT (2018), Travel time measures for the Strategic Road Network and local 'A' roads: January to December 2017 report, https://www.gov.uk/government/statistics/travel-time-measures-for-the-strategic-road-network-and-local-a-roads-january-to-december-2017

60   Parliamentary Office of Science and Technology (2016), Green Space and Health, https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0538

61   WSP and Farrells (2016), Making Better Places: Autonomous vehicles and future opportunities, https://www.wsp.com/en-GB/insights/autonomous-vehicles

62   Shared Mobility Simulations for Helsinki – ITF (2017), https://www.itf-oecd.org/shared-mobility-simulations-helsinki

63   Transport Systems Catapult for the Centre for Connected and Autonomous Vehicles (2017), https://www.gov.uk/government/publications/connected-and-autonomous-vehicles-market-forcecast

64   DfT (2018), NTS0905: Car occupancy, England: since 2002, https://www.gov.uk/government/statistical-data-sets/nts09-vehicle-mileage-and-occupancy

65   Commission on Travel Demand (2018), All Change? The future of travel demand and the implications for policy and planning, http://www.demand.ac.uk/commission-on-travel-demand/

66   DfT analysis using National Travel Survey 2017 data

67   Innovate UK (2015), The Low Carbon Vehicles Innovation Platform: an impact review, https://www.gov.uk/government/publications/the-low-carbon-vehicles-innovation-platform-an-impact-review

68   PwC (2018), The impact of drones on the UK economy - Skies without limits, https://www.pwc.co.uk/issues/intelligent-digital/the-impact-of-drones-on-the-uk-economy.html

69   Transport Systems Catapult, Intelligent Mobility – driving a £1.4 trillion market, https://ts.catapult.org.uk/intelligent-mobility/introduction/

70   Transport Systems Catapult for the Centre for Connected and Autonomous Vehicles (2017), https://www.gov.uk/government/publications/connected-and-autonomous-vehicles-market-forcecast

71   Clewlow, R. and Mishra, G. (2017) Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States, https://steps.ucdavis.edu/new-research-ride-hailing-impacts-travel-behavior/

72   Office for National Statistics (2018), Internet users, UK: 2018, https://www.ons.gov.uk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2018#recent-internet-use-by-disabled-adults-increases-across-all-ages

73   Financial Conduct Authority (2017), Understanding the financial lives of UK adults, https://www.fca.org.uk/publications/research/understanding-financial-lives-uk-adults

74   DfT (2018), Transport and Technology Public Attitudes Tracker - Waves 1 and 2. https://www.gov.uk/government/publications/transport-and-transport-technology-public-attitudes-tracker

75   See, for example, Gelauff, G., Ossokina, I., and Teulings, C. (2017), Spatial effects of automated driving: Dispersion, concentration or both, https://www.researchgate.net/publication/320101352_Spatial_effects_of_automated_driving_dispersion_concentration_or_both; Meyer, J., Becker, H., Boesch, P. M., and

Axhausen, K. W. (2017), Autonomous vehicles: The next jump in accessibilities?, https://www.sciencedirect.com/science/article/abs/pii/S0739885917300021

76 OECD (2018), Rethinking Urban Sprawl, http://www.oecd.org/publications/rethinking-urban-sprawl-9789264189881-en.htm

77 San Francisco County Transportation Authority (2018), TNCs & Congestion, https://www.sfcta.org/emerging-mobility/tncs-and-congestion

78 DfT (2018), Road Traffic Forecasts 2018, https://www.gov.uk/government/publications/road-traffic-forecasts-2018. These tests were conducted against a single uptake rate for connected and self-driving vehicles, and with assumptions taken from a limited evidence base. The uptake rate is highly uncertain and this single uptake rate is intended to represent a possible uptake for the purposes of modelling impacts.

79 DfT (2018), TSGB0116: People in employment in transport related occupations, April-June 2018, https://www.gov.uk/government/statistical-data-sets/tsgb01-modal-comparisons. Includes van drivers, taxi and cab drivers and chauffeurs, heavy goods vehicle drivers, bus and coach drivers, driving instructors and other drivers and transport operatives.

80 https://www.oecd-ilibrary.org/docserver/2e2f4eea-en.

81 The percentage of London buses that were horse drawn in 1900 is from the National Archives, http://www.nationalarchives.gov.uk/pathways/census/living/move/horse.htm. The date of the last horse-drawn bus in London is from the Museum of London, https://web.archive.org/web/20121202005111/http://www.museumoflondon.org.uk/postcodes/places/SE15.html.

82 DfT (2018), Inclusive Transport Strategy, https://www.gov.uk/government/publications/inclusive-transport-strategy/the-inclusive-transport-strategy-achieving-equal-access-for-disabled-people

83 DfT (2018), Transport and Technology Public Attitudes Tracker - Waves 1 and 2., https://www.gov.uk/government/publications/transport-and-transport-technology-public-attitudes-tracker

84 National Travel Survey (2017). Urban areas are those with a population of 10,000 or more. The discrepancy between the percentages in the graph and the cumulative percentage cited for trips under 5 miles is due to rounding.

85 Sustrans (2019), Bike Life -Transforming cities: The potential of everyday cycling, https://www.sustrans.org.uk/bikelifetransformingcities

86 BMJ (2017), Association between active commuting and incident cardiovascular disease, cancer, and mortality: prospective cohort study, https://www.bmj.com/content/357/bmj.j1456

87 F. de Leeuw et al., Assessment of personal exposure to particulate air pollution during commuting in European cities—Recommendations and policy implications, https://doi.org/10.1016/j.scitotenv.2014.05.036

88 DfT (2017), High Speed Two Phase Two strategic case, https://www.gov.uk/government/publications/hs2-phase-two-strategic-case

89 DfT (2018), Road to Zero strategy, https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy

90 DfT (2018), Road Traffic Forecasts 2018, https://www.gov.uk/government/publications/road-traffic-forecasts-2018. These tests were conducted against a single uptake rate for connected and self-driving vehicles, and with assumptions taken from a limited evidence base. The uptake rate is highly uncertain and this single uptake rate is intended to represent a possible uptake for the purposes of modelling impacts.r

91   DfT (2018), Transport and Technology Public Attitudes Tracker - Waves 1 and 2. https://www.gov.uk/government/publications/transport-and-transport-technology-public-attitudes-tracker

92   Kawalek, P. and Bayat, A (2017), Data as infrastructure – paper for the National Infrastructure Commission, https://www.nic.org.uk/publications/data-infrastructure-paper-national-infrastructure-commission

93   DfT (2018), Transport appraisal and modelling strategy: informing future investment decisions, https://www.gov.uk/government/consultations/transport-appraisal-and-modelling-strategy-informing-future-investment-decisions

94   DfT (2018), Road to Zero strategy, https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy

95   https://www.gov.uk/government/statistics/apprenticeship-and-levy-statistics-december-2018

96   DfT (2018), Transport infrastructure skills strategy: two years on, https://www.gov.uk/government/publications/transport-infrastructure-skills-strategy-two-years-on

97   DfT (2018), Good Work Plan, https://www.gov.uk/government/publications/good-work-plan