

# Scotland's Big Mo:



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# **Glossary of Terms**

The following terms appear in this report.

# **City Deals and Growth Deals**

In Scotland, these are agreements between the Scottish Government, the UK Government and local government designed to bring about long-term strategic approaches to improving regional economies. These packages may include funding for infrastructure, including transport. At present, there are City Region Deals for Edinburgh and South East Scotland, Glasgow City Region, Aberdeen City Region and Inverness and Highland City Region.

Discussions are taking place with Stirling and Clackmannanshire and the Tay Cities Region. Growth Deals are being discussed for other parts of Scotland. The Borderlands Initiative aims to promote inclusive economic growth in the areas on both sides of the Scotland-England border.

# Connected and Autonomous Vehicles (CAVs)

Connected Vehicles are vehicles that use any of a number of different communication technologies to communicate with the driver, other vehicles on the road, roadside infrastructure, and to other systems and services which are accessed via cloud computing.

Autonomous Vehicles (AVs) are those in which operation of the vehicle occurs without direct driver input to control the steering, acceleration, and braking and are designed so that the driver is not expected to monitor constantly the roadway while operating in self-driving mode.

The UK's Centre for Connected and Autonomous Vehicles supports the early market for both Connected and Autonomous Vehicles (CAVs). This report will use the term CAVs unless specifically discussing either Connected Vehicles or Autonomous Vehicles and not the other.

# **Digital Railway**

The rail industry's programme, led by Network Rail, to transform the rail network for passengers, business and freight operators by deploying modern signalling and digital train control technology to increase capacity, reduce delays, enhance safety and drive down costs. Remote Condition Monitoring will provide data to support predictive maintenance so that the reliability of infrastructure is improved, asset failures are minimised and costs are reduced.

# **Electric Vehicles (EVs)**

A vehicle which uses electric motors for propulsion. Plug-in EVs are propelled by electric motors, using electricity from external sources, such as wall sockets, stored in rechargeable batteries. Hybrid EVs combine a combustion engine with an electric propulsion system.

### FinTech

An emerging financial services sector that applies technology and innovation to processes, products and business models e.g. mobile banking, investing services and cryptocurrency.

# **Heavy Goods Vehicles (HGVs)**

A goods vehicle weighing between 3.5 and 44 tonnes.

### **Intelligent Transport Systems (ITS)**

The specification and deployment of innovative technology in transport. The definition of ITS changes as new technologies are developed. It will increasingly involve CAVs, EVs and MaaS.

# **Internet of Things (IoT)**

The interconnection via the Internet of computing devices embedded in everyday objects (e.g. vehicles, buildings, infrastructure and other items) enabling them to collect and exchange data.

# **Light Goods Vehicles (LGVs)**

A goods vehicle weighing not more than 3.5 tonnes.

# Low Emission Zones (LEZs)

Areas where the most polluting vehicles are regulated. Usually this means that vehicles with higher emission cannot enter the area. Alternatively they may need to pay to enter the zone.

# Mobility as a Service (MaaS)

Various forms of transport services, integrated into a single mobility service accessible by users on demand. MaaS has the potential to change the way people travel by giving them personalised, informed whole route choice based on their preference for a fare or subscription.

# National Transport Strategy (NTS)

The Scottish Government's long term vision for transport policies. It was first published in 2006 and refreshed in 2016. A full review is now in progress and a new strategy is due in 2019.

# Smart Motorways (or Connected Highways)

Roads which use innovative technology to actively control traffic flows by varying speed limits and using the hard shoulder as an extra lane to increase capacity and relieve congestion. These will increasingly use technologies (e.g. fibre optic cables, CAVs and drones) to provide real-time information to drivers and traffic control centres about congestion and conditions.

# Strategic Transport Projects Review (STPR)

The Scottish Government's 29 land transport investment priorities over the period to 2032. It was published in 2008. A new STPR will be started following the review of the NTS.

# **Ultra Low Emission Vehicles**

Any vehicle that uses low carbon technologies. This includes electric and hydrogen vehicles.

# **Foreword**

The development of this report has been a journey in itself.

SCDI first approached me to Chair a Transport Connectivity Commission following feedback from its members as it prepared its policy strategy for Scotland's economic future From Fragile to Agile: A Blueprint for Growth and Prosperity. It was that, while there is substantial long-term transport investment in Scotland, there is a perception that our networks are falling further behind internationally, risking loss of economic competitiveness. Rather than play catch-up, there is a need for transformational improvements to underpin action to address the key weaknesses in the Scottish economy in productivity, innovation and internationalisation.

The Commission decided early in its work that it would focus on land transport. This reflected the Scottish Government's Strategic Transport Projects Review and the City Region Deals which were then agreed or in development. However, as the Commission gathered and discussed evidence our focus moved from specific interventions to the more fundamental issue of transformative changes within the transport market, particularly due to digitalisation and decarbonisation, and the potential implications for connectivity in Scotland. As our work progressed the rationale for this change became stronger – it seemed that every week there was another announcement from the transport or digital industry, supported by eye-watering investment, or from national or local governments, on plans for connected and autonomous vehicles (CAVs), electric vehicles (EVs) or for new, digitally-enabled mobility services.

In particular, it does seem that we have reached an inflection point on EVs. The Scottish Government has set a target to end petrol and diesel car sales by

Looking forward, there is potential to meet the changing lifestyle needs of people and changing logistics needs of businesses much better with seamless, door-to-door connectivity.

2032 and other European countries are making their own commitments. Of great significance to the future of the global market is that China and India, concerned by the environmental and health problems in their cities, are committing themselves to ambitious targets and plans to ban these sales.

The disruptive influence of digital technologies, on-demand services and the sharing economy on established business models is already clear in other sectors and in parts of

the transport industry. While the Commission's focus has been land transport, there is applicability of many of the points in this report to all transport modes and to their integration at multi-modal hubs. Looking forward, there is potential to meet the changing lifestyle needs of people and changing logistics needs of businesses much better with seamless, door-to-door connectivity.

The scale and timing of the impact of Mobility as a Service (MaaS) – in which the legacy operationally-based model changes into a service-based model – and CAVs is the subject of much debate. There continue to be some well-publicised, and tragic, setbacks. There could be a wide range of positive and negative economic, social and environmental outcomes. We need to understand both so we can maximise the positives and minimise the negatives.

Radical changes to car ownership due to shared mobility would create the potential to release road capacity to re-engineer city centres and release land for large-scale redevelopment. On the other hand, there could be an increase in travel demand with the increased flexibility of car-based travel, which could potentially have a significant impact on socio-economically important public transport services. The way in which new modes are regulated will have a significant influence over whether the opportunities are realised and the risks are reduced.

On the railways, the roll-out of the 'Digital Railway' to modernise signalling and automate the control of trains could accommodate significantly more passenger and freight paths, but, again, there is uncertainty about the technologies, scale and timing.

All of this critically depends on the better maintenance and development of reliable and resilient transport infrastructure ready for these innovations; a world-class national digital infrastructure; and integration of energy and mobility systems. Developments across all three sectors are likely to create a nexus of energy, digital and transport infrastructure and services. There will be a need for a single, cohesive national strategy for all three, with strengthened regional integration of land use planning and delivery.

By the time the planned £3 billion A9 dualling project between Perth and Inverness is completed in 2025, it is possible that some of the first 'drivers' to complete the route could be CAV EVs. By the time the City Deal programmes for Scotland's city regions are completed in 20 years time, fleets of CAVs, could be providing mobility for people and goods in our cities.

The Commission has been particularly concerned with policy in Scotland and therefore many of the recommended actions are principally directed towards the Scottish Government and/or industry in Scotland.

We believe that the UK Government, Scottish Government, regulators and industry should seek to realise the benefits of the application of digital and low carbon technologies across all transport modes.

However, it recognises that key policy responsibilities and major decisions will be taken by governments, regulators and industry at UK, European and global levels. Even in their areas of responsibility government in Scotland will have to be in close contact with policy and industry developments at those levels to ensure an integrated approach.

In that context, the central message of this report is that strategic thinking needs to be undertaken as a matter of urgency. The Scottish Government needs to decide – following consultation with industry and city regions – if its vision is for Scotland to be at the forefront of some or all of these changes, or if it will plan to adapt current services and adopt new services as the market rolls them out. If the Scottish Government wants Scotland to be a location for these innovations, there needs to be a joined-up vision and approach and action is needed now. The

Scottish, UK and local governments, regulators and industry need to develop and promote opportunities which are attractive to global investment, future-proof infrastructure, and update and integrate legislation, regulation and decision-making processes.

We believe that the UK Government. Scottish Government, regulators and industry should seek to realise the benefits of the application of digital and low carbon technologies across all transport modes. To do otherwise risks entrenching the relative peripherality of Scotland and of areas within it. with negative economic and social consequences. We fully recognise that this report does not, and could not, provide all the answers, but it does identify the issues which need to be considered and recommends how this work should be taken forward. in good time so that we do not end up simply reacting to the effects of entrepreneurial interventions.

We would urge governments, regulators and industry to do so. The rate of change in mobility will only accelerate and the prize is potentially massive – a world-class, efficient connectivity system which helps to drive higher productivity, innovation and internationalisation, while supporting the low carbon transition.

George Hazel, Chair, Connectivity Commission



# **Executive Summary** Recommendations

# **Executive Summary - Recommendations**

Connectivity, for people and for freight, is changing globally and, over the next decade, is likely to be transformed at an accelerating rate. In transport, digital technologies are expected to significantly alter the demand for services and the way in which they operate – with opportunities and risks for connectivity, capacity, congestion and integration. This could, in turn, lead to a wide range of changes for our economy, society and environment, both positive and negative, including where we live and in how we access employment, services and amenities.

These will not proceed at the same rate everywhere, with the rate of transformation most rapid within and between city regions, especially those which, globally, are the most attractive markets and/or which most encourage these developments. However, it would appear inevitable that transport services in all major urban centres will be fundamentally changed and that this is also highly likely to then change and challenge the availability of services in smaller urban, rural and remote areas.

Both the UK and Scottish governments have been taking an increasing interest in technological changes in transport, especially in supporting, stimulating and, now, driving the market for EVs. The UK Government has created the Centre of Connected and Autonomous Vehicles and has been actively seeking to understand MaaS1 and the potential opportunities and challenges. The Scottish Government is starting to develop strategic thinking about these changes as part of the review of the National Transport Strategy. In relation to MaaS, both governments seem to be watching how the market evolves and are uncertain about their roles and responses.

City Region Deals have been or are close to being agreed, all of which are prioritising transport connectivity projects, without apparent consideration (yet) of these potentially transformative developments. While this is understandable given the uncertainties, there are also significant potential risks from these changes to Scotland's current connectivity – risks which may be even higher if the Scottish Government does not at an early stage seek to shape them in a positive way – and potential missed opportunities, both to improve Scotland's connectivity and realise industrial opportunities.

The review of the National Transport Strategy will, it is understood, articulate the long-term transport policy priorities for Scotland. This is planned for completion in 2019 and will be followed by a revised Strategic Transport Projects Review which will set out investment priorities. Both will need to align with the refreshed Scottish Digital and Energy strategies and next iteration of the National Planning Framework.

The central message of this report is that this strategic thinking needs to be undertaken as a matter of urgency. The Scottish Government needs to decide, following consultation with industry and city region authorities, if its vision is for Scotland to be at the forefront of some or all of these changes, or if it will plan to adapt current services and adopt new services as the market rolls them out. Scotland has some world-class transport, digital and energy companies, skills and research, and the ability to create collaborations at national and city region levels. If the Scottish Government concludes that it wants Scotland to be a location for these innovations, it needs to act now, with industry and city region authorities, to develop and promote opportunities which are attractive to global investment.

The Connectivity Commission has developed recommendations for Government, industry and regulators to consider in relation to four key themes, namely:

- Policy and regulation
- Funding and business models
- Approaches to evaluation and prioritisation
- A focus on mobility and integration

# **Government policy and regulation**

- 1. Adoption of a fully integrated approach to Scottish Government policy development across all the aspects of infrastructure that enable connectivity. The issues that are identified in this report must be the immediate priority for the review of the National Transport Strategy and the revised Strategic Transport Projects Review but also a key priority for the more recently developed Energy Strategy and refreshed Digital Strategy.
- 2. Working closely with industry, seek to realise the benefits of the application of digital and low carbon technologies across all transport modes through policies that will:
  - a. enable the roll-out of in-vehicle technologies that support the efficient use of road space and rapid development and implementation of CAVs for both freight and passenger traffic
  - b. enable the roll-out of the digital railway, modernising signalling and automating the control of trains to accommodate more passenger and freight paths, along with strategic investment in key routes
  - c. rapidly enable smart, integrated planning and payment methods and smart logistics systems, and enhance multi-modal travel

- information, to support door-todoor journeys. The potential for new payment methods should be explored with the FinTech sector
- d. urgently develop a data strategy to protect personal data and unlock the benefits of sharing data for users, operators and networks
- e. continue to electrify the rail network, potentially including development of new battery technologies, and support the rollout of infrastructure to fuel low carbon vehicles, considering both electric and hydrogen options, and the development of smart charging arrangements
- f. strengthen regional integration of transport, digital and energy with land use planning and delivery, to enable sustainable population and economic growth, tackle congestion, and increase active travel
- g. develop an industrial strategy that provides a clear policy direction and a framework for pilots and partnerships that will enable inclusive growth for a low carbon highly connected economy.

### **Funding and business models**

3. Addressing the issue of investment funding and how this could be generated from government agencies, funders and industry will be critical going forward, as the dynamics of the required infrastructure and the business models for delivery and use of that infrastructure evolves. The Scottish Government needs to act as a focal point to establish and implement new ways of funding road and rail infrastructure, including the digital and energy infrastructure to support CAVs and MaaS, to meet the new investment demands as well as offset the potential offset loss of

- revenue from fuel duty. There is also the potential that the pay as you go and dynamic pricing systems that will underpin MaaS will generate revenue streams, which can be effectively captured and utilised. Government also needs to promote new ways of funding, like Land Value Capture, to help meet the cost of future connectivity systems.
- 4. The Scottish Government and industry should review how, with the emphasis in the technology sector on scale, network effects and control of data, competitive markets at a city region level could be maintained and the barriers to entry could be low enough for innovative services.

### **Evaluation and prioritisation**

5. The Scottish Government should broaden its assessment methods for investment in improvements to and the operation and maintenance of Scotland's transport networks as well as consider how such investment decisions can be prioritised both within transport but also across other critical enabling infrastructure such as digital and energy networks. Given the uncertainties about future developments, scenariobased assessments are recommended. Transport networks should be reviewed and re-shaped to best deliver future demand and services, economic, social and environmental outcomes, reliability, resilience, and affordability. The apparently substantial additional costs of new infrastructure projects in Scotland and the UK compared to most other European countries should be fully analysed and addressed.

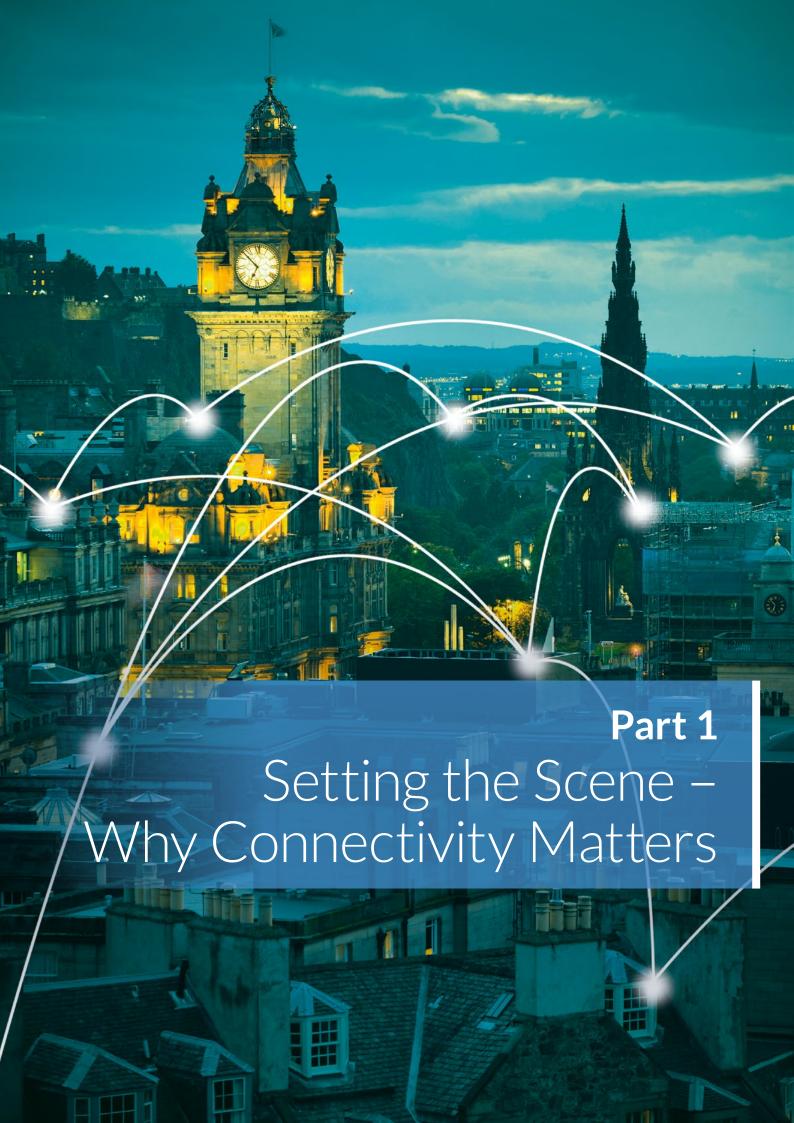
# A focus on mobility and integration

6. The Scottish Government, industry and regional and local authorities should discuss the potential

- implications, including the risks and opportunities, for inclusive growth of new technologies and business models in transport services, such as MaaS. These include: demand for and funding of socio-economically important services, especially but not only in rural and remote areas; how services could be adapted to continue to be provided; and how new digital services models like MaaS could support these services, or whether the market would need to be regulated or support services provided, to ensure that dynamic pricing does not further disadvantage people living in poverty. Performance indicators should be discussed and set for transport services linked to national and regional outcomes.
- 7. The UK Government, Scottish Government and industry should review transport legislation and regulations to ensure that they are fit-for-purpose for changes in transport delivery, such as MaaS, to allow operators to respond much more rapidly and flexibly to data showing changing demand, or to partner to integrate or provide services in a different way; enabling door-to-door journeys, protecting socioeconomically important availability and/or improving efficiency.

### **Establish a Partnership Board**

8. To act as a catalyst for change and to promote collaborative working, a Future Mobility Partnership Board of industry, government and regulators should be formed to further review the specific opportunities and challenges identified in the report and present recommendations to the Scottish Government to inform its strategic thinking. This group should particularly focus on the four key themes that have been identified by the Commission.



# Part 1 – Setting the Scene – Why Connectivity Matters

Improvements in transport connectivity based on the development of new technologies have been a key element of the industrial revolutions and productivity growth over the last two hundred and fifty years – from canals, to railways, steam ships, road vehicles, motorways and air transport.

World-class transport connectivity is of fundamental importance to the success of modern economies. This is a report by a Transport Connectivity Commission on the Movement of Things. However, transport is coming to mean not only the movement of people and goods, but information as well, and we should think how we integrate all of these elements.

In countries with relatively well-developed transport infrastructures, such as the UK, incremental improvements to connectivity do not generally, in themselves, result in instant growth in productivity. Rather, they support productivity growth more effectively when investment is targeted and aligned with other investments, such as in skills development and economic regeneration<sup>3</sup>.

International production, trade and investments have become increasingly organised within global value chains in which the different stages of the production process are dispersed across countries<sup>2</sup>. Companies have also employed just-in-time strategies in logistics to increase efficiency and decrease waste.

City regions have become ever more important globally in economic growth, clustering businesses and skills which generate economic activity and strengthening economic links with other city regions. The rapid growth of e-commerce has particularly driven the intensification of urban freight distribution. While digital technologies are transforming opportunities for videoconferencing and flexible working, increased connectivity has also increased the reach of extended business markets and personal networks, and therefore created new opportunities for corresponding demand for person-to-person contact.

Transport connects businesses with skills and people with jobs; is the basis for efficient supply chains and distribution systems for raw materials and finished products; and enables and develops marketplaces in which businesses and people can trade and innovate. The travel and tourism industry is one of the world's largest and fastest-growing industries. Places with reputations for high-quality, reliable and affordable transport

networks are more attractive locations in which to invest, live and visit.

Improving connectivity between areas with different levels of economic activity can help distribute economic growth between them, supporting economic regeneration and inclusive growth. Good transport links can play an important role in place-making through increasing accessibility and connectivity of an area.

There are also potential economic downsides from transport investment, for example increased levels of pollution and congestion, displacement of activity, or induced demand leading to only short-term benefits. Potential disadvantages need to be fully considered in the development process.

In countries with relatively well-developed transport infrastructures, such as the UK, incremental improvements to connectivity do not generally, in themselves, result in instant growth in productivity. Rather they support productivity growth more effectively when investment is targeted and aligned with other investments, such as in skills development and economic regeneration<sup>3</sup>. This helps to retain their relative competitive position and attractiveness for investment.

For Scotland – as a relatively small, open economy on the edge of Europe – improving connectivity, internally and

with external markets, and optimising the benefits, is regarded as especially significant.

Scotland's National Transport Strategy, currently under review, has three key strategic outcomes:

- Improved journey times and connections between our cities and towns and our global markets to tackle congestion and lack of integration and connections in transport
- Reduced emissions to tackle climate change, air quality, health improvement
- Improved quality, accessibility and affordability of transport, to give choice of public transport, better quality services and value for money, or an alternative to car.

The changes discussed in this report will influence all of them and the wider outcomes<sup>4</sup> in Scotland's *National Performance Framework*.

Scotland's city regions each offer a unique input to Scotland's economic growth<sup>5</sup>. They are facing increasing competition in the UK, not only from London but from the so-called Northern Powerhouse and metro regions in England, where substantial investment in connectivity is planned, and internationally.

Congestion on transport infrastructure in Scotland's largest city regions is among the worst in the UK<sup>6</sup>. While congestion

remains a serious problem for cities across Europe, there is some evidence that traffic congestion in the UK's biggest urban areas has trended upwards in recent years, whereas it has shown a decline on average in urban areas in other parts of Europe<sup>7</sup>. Congestion reduces productivity and leads to poorer air quality and quality of life.

Scottish cities are working together to present a more competitive proposition for global investment<sup>8</sup>, developing city region partnerships with long-term strategic approaches to improving economic performance. Every Scottish city has been, or is, in negotiations with the UK and Scottish governments to have a City Deal to support their growth. Improvements to intracity and intercity connectivity within Scotland are priorities for Scotland's city regions and improvements to cross-border connectivity are priorities for them and for the Borderlands Initiative for enhanced cooperation between the south of Scotland and the north of England.

Many of the major post-devolution improvements have been in the transport connections between Scotland's cities, with fewer at a city region level. Even so, some of the road and rail connections between Scotland's cities generally

lack capacity and resilience, and/or offer poor journey times compared with many other countries. In the case of some rail routes, journey times are slower than 100 years ago<sup>9</sup>. The need to serve growing commuter towns has also increased end-to-end journey times over the past 40 years. So the Scottish Government's planned major improvements continue to emphasise intercity connections - completing the dual carriageway intercity road network, specifically the A9 and the A96, and rail improvements (although comparatively lower investment) to the Aberdeen to Inverness Line and Highland Main Line.

Key Scottish sectors and companies which operate in the global market rely on strong domestic transport connectivity linking with international connectivity to export or to attract business. Scotland's major production sites are concentrated in specific areas, both urban and rural, and freight movements to and from international gateways often use the same infrastructure as intercity traffic. Constraints on transport connectivity may, therefore, restrict businessto-business links between cities, opportunities for tourists to travel to all places they may wish to visit, especially on shorter breaks, and the capacity of freight transport.

Key Scottish sectors and companies which operate in the global market rely on strong domestic transport connectivity linking with international connectivity to export or to attract business.

<sup>4</sup> Scottish Government, http://www.gov.scot/About/Performance/scotPerforms/outcome

<sup>5</sup> Scottish Government (2011), Scotland's Cities: Delivering for Scotland

<sup>6</sup> INRIX Roadway Analytics (November 30th, 2016), INRIX Reveals Congestion At The UK's Worst Traffic Hotspots To Cost Drivers £62 Billion Over The Next Decade

<sup>7</sup> Begg, D (2016), The Impact of Congestion on Bus Passengers

<sup>8</sup> Scotland's Seven Cities (2015), A Shared Vision for Scotland's Success

<sup>9</sup> Transform Scotland (2014), Intercity Express

The implications for the economy, society and environment are potentially immense. Those economies which maximise the benefits could experience a great leap in their connectivity and competitiveness.

The Commission fully recognises that a system which operates seamlessly only in and between cities would not offer seamless connectivity.

Investment in physical infrastructure inevitably results in a period of disruption, and recent upgrades in key road and rail infrastructure have highlighted that people and businesses need and value reliability, and the importance of strengthening resilience to environmental changes. Many businesses place great value on the predictability of journey times and can incur cash penalties for late delivery to their clients and/or customers. Reliability and resilience should become explicit to the strategic outcomes for transport in Scotland.

The Commission agrees that substantial investment in maintaining and developing Scotland's transport infrastructure and services should continue to be a high priority. However, strategic projects have been the focus of

many studies so the Commission decided not to comment on specific projects. The report does, nevertheless, highlight the new challenges to the planning of future major physical infrastructure.

What it means to offer world-class transport connectivity is changing. A new infrastructure revolution is under way. Digital innovations are making possible the introduction of intelligent mobility systems which will "cut across and go beyond the traditional transport sector"10, encompassing, in the shorter-term, Smart Motorways (connected cars and highways), big data, smart, integrated planning and payment methods (contactless, mobile, smartcards), multi-modal travel information, MaaS and smart logistics, and, in the longer-term, fully autonomous vehicles and the 'Digital Railway'. The need to tackle climate change and improve air quality is, at the same time, the impetus for a transition to cleaner fuels.

Together, these will enable a general shift in mobility over time from high carbon to low carbon, from operator-based to user-based and from personally-owned to shared door-to-door, seamless mobility solutions that are consumed as a service, e.g. MaaS.

The implications for the economy, society and environment are potentially immense. Those economies which maximise the benefits could experience a great leap in their connectivity and

competitiveness. There are potential downsides which should be recognised and understood. However, the positive potential for connectivity in Scotland could out-weigh any negatives. This report will, in a Scottish context and from a Scottish perspective, explore the drivers for change and the most important areas for government and industry in Scotland to consider, and, based on this, propose recommendations. The aim, ultimately, is maximising the benefits and minimising the downsides for Scotland.





# Part 2 - Drivers of Change

Scotland has a modern transport network. In overall terms, it is much less densely populated than England and its geographically extensive road and rail networks are, therefore, much less intensively utilised. However, the city regions in Central Scotland<sup>11</sup> and Aberdeen have some of the most congested road infrastructure anywhere in the UK, and the rail network in the west of Scotland is the most heavily used commuter network in the UK outside London<sup>12</sup>.

There have been substantial investments in transport infrastructure and service enhancements made by successive Scottish Governments in the 20 years since devolution.

Key road projects completed include the M80 extension, the M77 extension and Glasgow Southern Orbital, the M74 completion and, more recently, the Queensferry Crossing and M8/M73/M74 completion project, with a combined capital construction value in excess of over £3bn. The Aberdeen Western Peripheral Route is due for completion in the Autumn 2018.

Key rail projects completed include the Borders Railway, Stirling-Alloa-Kincardine and Airdrie-Bathgate. Investment in rail infrastructure and services between 2014 and 2019 totals up to £5bn. This includes the Edinburgh Glasgow Improvement Programme – that incorporates electrification in Central Scotland and new rolling stock – and the Aberdeen-Inverness rail improvements project, as well as station upgrades across the network and other capital projects. A Scottish Strategic Freight Network is to be developed on Scotland's railways.

The National Cycle Network is increasingly being extended from long-distance routes for tourists to local urban route networks<sup>13</sup>. However, there have been a number of recent setbacks to the provision of existing and new segregated cycle routes in cities and towns<sup>14</sup>.

What is also evident from transport statistics is that the performance of Scotland's transport system has, in many but not all respects, been steady rather than greatly changed over the last decade.

Many of these projects have met and exceeded anticipated benefits in their strategic business cases, supporting local, regional and national economic development and regeneration.

However, what is also evident from transport statistics is that the performance of Scotland's transport system has, in many but not all respects, been steady rather than greatly changed over the last decade. Relatively modest economic growth since the financial crash in 2008 has been a major cause.

The following section presents information on the Scottish land-based transport system, particularly on the measures which Transport Scotland has used to assess its performance and key trends since the publication of Scotland's National Transport Strategy in 2006<sup>15</sup>.

In 2016-17, 16.9% of the motorway network, 10.7% of the dual carriageway and 11.5% of the single carriageway trunk road network required close monitoring of the state of the road surface, while 29% of the local authority A road network and 36% of the whole of the local authority network may require some

<sup>11</sup> Daily Record (October 17th 2016), Scotland's most congested road revealed

<sup>12</sup> Transport Scotland (2006), Scotland's Railways

<sup>13</sup> Sustrans

<sup>14</sup> The Scotsman (November 2nd 2016), Task force launched after cycle routes axed

<sup>15</sup> Transport Scotland (2018), Scottish Transport Statistics, No 36, 2017 Edition

kind of maintenance<sup>20</sup>. The Society of Chief Officers of Transportation in Scotland (SCOTS) has suggested that the existing backlog of repairs to Scotland's non-trunk road networks was valued at £1.6bn<sup>21</sup>.

Scotland's railways have had record investment in recent years and there have been many significant modernisations. However, much of the network was built in the 19th century, including signalling, track and structures, and there are a significant number of assets classified as poor or deteriorating, especially bridges<sup>22</sup>. In excess of £2bn in renewals projects are planned between 2019 and 2024<sup>23</sup>, which Transport Scotland plans to link to projects to improve services to minimise disruption and invest efficiently<sup>24</sup>.

### Conclusion

The need for change is evident from Scotland's transport statistics. With demand for transport forecast to continue to increase, there is a risk that performance will deteriorate. This further highlights the need for change – and the next section of this report will discuss changes on both the demand and supply side of mobility that are coming.

In In	frastructure
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Roads	56,250km of roads, with 3,669km of motorways and trunk routes
	Vehicles licensed grew from 2.6 to 2.9m between 2006 and 2016
	Four of the ten worst traffic 'hotspots' in the UK are on the Edinburgh City Bypass and one in Glasgow, with the cities ranked second and third behind London for the forecast costs to drivers in 2025 of congestion, together totalling $\pm 5.1$ bn¹6
	A further study found Aberdeen to be the third most congested city in the UK behind London and Manchester <sup>17</sup>
	Evidence that congestion in UK cities continues to increase
	Bus journey times increasing by almost 1% per annum, leading to higher costs and fares, increased journey times, and punctuality and reliability decline <sup>18</sup> . This is damaging the bus market and the economy, and is bad for pollution.
Railways	2,819 km of rail track and 359 stations at the end of 2016/17
	Considerable variation in character
	Cross-border and many interurban lines double track but rural lines and some intercity lines within Scotland largely single track
	Operational technologies vary from computer workstations to mechanical lever frame signal boxes (particularly on rural routes)
	Some routes (e.g. cross-border) partially cleared for largest freight traffic on GB network others with relatively limited gauge capability
	26% of the network electrified (cross-border and many Central Scotland routes) but lower proportion than for the GB network as a whole (33%) and with some first generation wires now aged
	Many key routes have no diversionary options or have diversionary options which lack the necessary gauge for large freight traffic increasing the challenges caused by disruptions <sup>19</sup>
Cycling	3,815 km of National Cycle Network routes
Routes	1,036 km of traffic-free routes

<sup>16</sup> Inrix Roadway Analytics (2016) INRIX Reveals Congestion At The UK's Worst Traffic Hotspots To Cost Drivers £62 Billion Over The Next Decade

<sup>17</sup> http://inrix.com/press-releases/traffic-congestion-cost-uk-motorists-more-than-30-billion-in-2016/

<sup>18</sup> Begg, D (2016), The Impact of Congestion on Bus Passengers

<sup>19</sup> Network Rail (2013), Strategic business plans 2014-19

<sup>20</sup> Transport Scotland (2018), Scottish Transport Statistics, No 36, 2017 Edition

<sup>21</sup> www.scottishconstructionnow.com/22167/repairing-scotlands-1-6bn-backlog-of-damaged-roads-deemed-impossible/

<sup>22</sup> Network Rail (2013), Strategic business plans 2014-19

<sup>23</sup> Network Rail (2018), Route Business Scotland Route Strategic Plan

<sup>24</sup> Transport Scotland (2018), Rail Enhancements and Capital Investment Strategy

# **Passengers**

Cars	Car volumes on the roads increased between 2006 and 2016, with total traffic up by 5% to 46.4bn vehicle-km per annum			
Buses	Bus transport remains the most commonly used form of public transport, accounting for 393m journeys or 75% of all public transport journeys, but the number has decreased by 15% between 2006 and 2016			
ScotRail Trains	Journeys increased by 32% between 2006 and 2014 to 94.2m			
	Some routes carry twice as many passengers as they did 20 years ago			
	Some services currently run at nearly 150% of planned capacity at peak <sup>25</sup>			
Bikes	Cycling km increased by 35% between 2006 and 2016			
	1.2% of journeys (the Scottish Government's target is 10% in 2020)			

# Freight<sup>26</sup>

Total Freight	The volume of freight lifted fell 12% between 2006 and 2012
	Road freight accounted for 42% of total tonne kilometres, shipping for 30% and rail for 9%
	Limited modal shift from road
Rail Freight	Tonnes lifted per annum fell from 14.3 to 8.4m between 2006 and 2012 <sup>27</sup>
	Over 40% reduction of freight moved to, from and within Scotland <sup>28</sup>
Lights Goods Vehicles	Mileage increased by 28% between 2006 and 2016 (5,365m vehicle km to 7,368 vehicle km)
	16% of all traffic in 2016

# Socio-Economic Differences

Income	People in low-income households are much more likely to walk or take the bus to work and much less likely to drive or take the train than people in high-income households <sup>29</sup>
	Car ownership continues to correlate significantly with income. Among lowincome households, 64% do not have a private car, compared to 2% of high-income households <sup>30</sup>
	Taxis and private hire vehicles key transport services for some journeys for some low-income households <sup>31</sup>
Disabled People	Less likely to use rail or bus services. Around 10% report difficulties getting to rail, bus or coach station or stop, and around 10% had difficulties getting on or off these forms of transport <sup>32</sup>
	Taxis and private hire vehicles are also key transport services for some journeys for some disabled people <sup>33</sup>
Urban/ Rural	Car ownership continues to vary between urban and rural areas
	Around 85-88% of households in rural areas have at least one car, compared with 60% of those in large urban areas
	Generally, much lower bus and train availability in rural areas
Age	36% of bus journeys are made under the National Concessionary Travel Scheme

- 25 Transport Scotland (2017), ScotRail's Top 10 Busiest Trains
- Transport Scotland report that difficulties obtaining updates to the data covering all the rail freight companies mean that the latest available data is for 2012/13. This also affects statistics for total freight lifted and modal share. After falling between 1960 and 1994-5, rail freight traffic increased in most years until 2005, when it began to decline again.
- 27 Between 2012-13 and 2016-17, the mass of freight goods carried on the GB rail network declined from 113.1 to 79.4m tonnes, a 30% reduction:  $http://dataportal.orr.gov.uk/displayreport/report/html/8db1c1b2-1a53-4db1-8347-ce248a12abb5\ .\ This was largely due to the decline in coal traffic.$ See 'Environment' section
- 28 Network Rail (2018), Route Business Scotland Route Strategic Plan
- 29 Transport Scotland, http://www.transport.gov.scot/report/j450918-09.htm#Table13
- 30 Transport Scotland, http://www.transport.gov.scot/statistics/statistical-trends/private-transport 31 Transport Scotland (2016), Going Further: Scotland's Accessible Transport Framework 32 Transport Scotland (2016), Going Further: Scotland's Accessible Transport Framework 32 Transport Scotland (2016), Going Further: Scotland's Accessible Transport Framework

- 33 Capability Scotland (2009), Disabled people's experience of using accessible taxis in Scotland



CO <sub>2</sub> Emissions	Fell by 11% from 14,762 to 13,145 MtCO2e between 2006 and 2016. But transport's share of total emissions has increased to 27% because emissions in other sector have fallen faster
Ultra-low emission vehicles	Increased (from a low base) 8 fold since 2013 Q1 and 66% since 2016 Q3 to 2,004 registered in Scotland for the first time in 2017 Q3



# National Outcomes

There are three transport-specific National Indicators in Scotland's current  $^{34}$  National Performance Framework. This is intended to measure and report on how Scotland is doing against a wide range of economic, social and environmental indicators and targets  $^{35}$ .

Congestion	Levels of road traffic congestion are similar		
	11.7% of car driver journeys perceived delayed due to traffic congestion, down 1% since 2006 and 3% since the 2007 peak		
Modal share	The proportions of total journeys made by car and by public or active transport (bus, train, tram, cycling or walking) have stayed relatively constant		
	Lack of behavioural change		
	Overall public and active travel to work has remained at around 30% for the last decade		
	The average car occupancy rate has decreased very slightly from 1.58 people per car journey in 2006 to 1.51 in 2014		
Road safety	Improved significantly		
	The overall number of reported road accidents fell by 36% between 2006 and 2016		

<sup>34</sup> The National Performance Framework is currently being refreshed and the Scottish Government is preparing to drop congestion and road safety as National Indicators, because these are seen as sectoral specific measures: www.parliament.scot/S5\_Local\_Gov/Inquiries/Page\_41\_-\_Comprehensive\_view\_of\_the\_development\_of\_the\_new\_Indicator\_set.pdf

<sup>35</sup> www.gov.scot/About/Performance/scotPerforms

# **Change is Coming**

A wide range of potential political, economic, social and environmental changes will influence future demand and the Commission recognises that there is significant uncertainty around them all.

# **Policy Context**

# Developments in Scotland Fiscal Framework

The new fiscal framework for the Scottish Government underpins the further powers over tax and welfare that has been devolved to the Scottish Parliament through the Scotland Act 2016. This delivers increased tax powers and therefore an increased reliance on tax generated in Scotland to fund the Scottish budget. Following the constraints on capital and revenue budgets which have been in place since 2010, these tax receipts will have an increasing influence over whether public finances continue to be sufficient to meet future demands.

This will require government to consider a more strategic approach to investment decision-making in Scotland to:

- Ensure best use of scarce resources, targeted at inclusive economic growth
- Increase the potential to maximise the Scottish Government's tax-take
- Offer external investors clarity and confidence in the Scottish Government's long-term investment priorities
- Enable action to be taken at the appropriate spatial level whether that is local, regional or national.

That strategic approach will need to be driven by a number of policy initiatives currently under consideration, or in action, that collectively will have a significant impact on the deliverability of these objectives.

### Prioritisation

As the Scottish Government makes the necessary transition to its own Treasury-led approach to financing and budgeting, there is strong evidence that supports the need to further develop decision-making processes. As current project commitments run their course, this enhanced decision-making framework will need to increasingly influence investment decisions, ensuring they:

- Are transparent, readily understood and, where possible, consistent with existing selection processes
- Consider both new and existing assets, to ensure cost-effective asset-stewardship
- Maximise delivery of essential infrastructure to ensure best returns for scarce resources
- Are outcomes-focussed, for example on the delivery of the National Outcomes in the National Performance Framework
- Are based on sound evidence, building on best-practice both within the Scottish Government and elsewhere
- Are both deliverable and affordable.

# **Enabling Programmes**

There are several key strands in this evolution which manifest:

- cross boundary, cross sector or cross organisation collaboration and in many cases all three
- strategic thinking, focused on inclusive growth

 focussing not only on infrastructure assets, but also encompassing many aspects of service delivery and skills and increasingly aimed at practical deliverable outcomes not simply the enabling assets being funded.

# **Empowered Planning**

A review of the Scottish planning system<sup>36</sup> has led to the introduction of a Planning Bill this year. Themes which have been the focus of the review are the need to develop a planning environment that is amongst other things:

- Strategic in design and intent, whilst being more delivery and outcome focused
- Streamlined in process, to accelerate development particularly in relation to housing
- Infrastructure-led, distinguishing between assets which enable development and those which are needed as a result of a development.

# **Brexit**

While the Commission started its work in advance of the vote, it has prepared this report in the period after the UK referendum on EU membership voted for Brexit. A significant proportion of the current law and technical standards applicable to transport and digital systems and operations in the UK are determined or otherwise derived from EU law. The basis and implications of the UK ceasing to be a member of the EU remain uncertain, for example in migration, innovation, and investment. Different regulatory approaches appear to be possible in relation to a number of the matters referred to in the report, including CAVs and MaaS, for which there is not a global

consensus at present. Accordingly, this report is not predicated on any regulatory assumptions.

### **Demand**

Demographic and Social Changes The population of Scotland is projected to rise by 5.3% over the next 25 years, from 5.4m in 2016 to 5.69m by 2041, and continue to rise into the future<sup>37</sup>. Over the next 10 years, population growth is projected to be predominately in the central belt and city regions<sup>38</sup>. These are regions which have already experienced substantial growth in recent decades – growth with which infrastructure development, including transport, has often not kept pace. Cities have also experienced densification of population and economic activity in their city centres<sup>39</sup>. Meanwhile, some non-city areas are projected to decline in population over the next 10 years<sup>40</sup>.

Scotland's population is also ageing. Taking into account the planned changes in the state pension age, the working age population is forecast to increase by 5% between 2016 and 2028, but then decrease to 2041 so that there is only a 1% increase between 2016 and 2041. Meanwhile the number of people of pensionable age is forecast to increase by 25%<sup>41</sup>. Growth in the working age population is again projected to be strongly concentrated in and around Scotland's cities. A third of Scotland's local authority

areas are expected to experience a decrease over the next 10 years<sup>42</sup>.

Scotland's employment rate has recovered following the 2008 Financial Crash, but, as with other advanced economies, there has also been a rise in the proportion of 'non-standard' jobs, including part-time work, temporary work, fixed-term contracting and subcontracting, self-employment and homework. The UK Commission for Employment and Skills has identified a range of trends that will shape future jobs and skills, including a desire for an improved work/life balance and changing work environments, potentially leading to a further increase in flexible working arrangements, with 57% of employees saying flexible working is important to them<sup>43</sup>.

Estimates of the scale of potential for automation vary between reports. What is clear, from all studies, is that many current jobs will either be replaced or changed fundamentally by automation<sup>44</sup>.

Research from the Resolution Foundation described Millennials – those leaving school since 2000 – as "on course to become the first generation to earn less than the one before"; with much lower levels of home ownership<sup>45</sup>. There are also more positive cultural reasons for lower levels of ownership. There appears to be decreased desire to own products<sup>46</sup>. Millennials rent on-demand

# Currently, demand for mobility is forecast to increase substantially.

through subscription services and have driven the growth in online marketplaces. The sharing economy is expected to continue to grow strongly and affect sectors like transport.

While the number of vehicles licensed for road use has continued to increase steadily in Scotland to 2.9m in 2014<sup>47</sup>, as in other developed countries, there are some indications of a plateau or peak in vehicle ownership and usage. Between 1993 and 2011, the proportions of 17 to 20-year-olds and 21 to 29-years-olds with driving licenses fell from 48% to 31% and from 75% to 66%<sup>48</sup>. Kilometres driven per capita have declined in the UK since the early 2000s<sup>49</sup>.

Currently, demand for mobility is forecast to increase substantially. For example, Network Rail's long-term planning is based on growth between 2012 and 2043 in the Edinburgh morning commuter market (115%), Glasgow morning commuter market (128%), Aberdeen morning commuter market (226%), interurban market (197%) and rural market (158%)<sup>50</sup>. Based on a number of assumptions including no fundamental change in behaviour, the Scottish Government has forecast that there will be a 27% increase in car km to 2035<sup>51</sup>.

- 37 National Records of Scotland (2017), Projected Population of Scotland (2016-based)
- 38 National Records of Scotland (2018), Population Projections for Scottish Areas (2016-based)
- 39 CityGeogrpahics, https://citygeographics.org/2013/09/09/an-urban-renaissance-achieved-mapping-a-decade-of-densification-in-uk-cities/
- 40 National Records of Scotland (2018), Population Projections for Scottish Areas (2016-based)
- 41 National Records of Scotland (2017), Projected Population of Scotland (2016-based)
- 42 National Records of Scotland (2018), Population Projections for Scottish Areas (2016-based)
- 43 UK Commission for Employment and Skills (2016), The Future of Work: Jobs and Skills in 2030
- 44 SCDI, BT Scotland, ScotlandIS and the RSE (2018), Automatic...For The People?
  45 Resolution Foundation (2016), Stagnation Generation: The case for renewing the intergenerational contract
- 46 Harris (2015), Millennials Fuelling the Experience Economy
- 47 Transport Scotland (2018), Scottish Transport Statistics, No 36, 2017 Edition
- 48 Department for Transport (2017), Driving licence holding and vehicle availability
- 49 Schroders (2015), The end of the road: Has the developed world reached 'peak car'?
- 50 Network Rail (2016), Scotland Route Study
- 51 Scottish Government (2018), Scotland's Action on Climate Change

There are uncertainties around these trends. For example, the level of migration is hard to estimate and will be a key influence on future population trends. Densification may continue in cities, with City Deals acting to induce further demand, or widespread flexible working patterns and growth in CAVs may encourage people to move out of cities.

It is suggested by the Commission that – while acknowledging the uncertainties – the following are likely to be priorities:

- Accommodating and managing increased and more flexible demand for travel
- Connectivity increasingly driven by the user and not by the operator
- Connectivity in and between city regions to support economic growth
- Changing legislation and regulation to enable the sharing economy
- Inclusive growth for the young, families and pensioners, and for urban and rural areas.

### Environment

### Reducing Carbon Emissions and Pollution

Scotland has the most challenging climate change legislation in the UK, with a long-term target to reduce emissions of greenhouse gases by at least 80% by 2050 relative to 1990. Following the Paris Agreement on Climate Change, the Scottish Government has committed to introducing a new Climate Change Act with a target of reducing emission by more than 50% by 2020.

The most recent report by the Committee on Climate Change that "there has been little progress in reducing emissions from transport, due to improved vehicle efficiency being offset by increased demand for travel as the economy has grown and fuel prices have fallen<sup>54</sup>.

Transport is estimated to account for 25% of Scotland's total energy use. Passenger transport accounts for around 60% of this use, with goods around 40%<sup>52</sup>. Road transport accounts for 73% and rail transport 1.3%<sup>53</sup>. Scotland is generally meeting and exceeding climate change targets, but the most recent report by the Committee on Climate Change that "there has been little progress in reducing emissions from transport, due to improved vehicle efficiency being offset by increased demand for travel as the economy has grown and fuel prices have fallen"<sup>54</sup>.

Over the last year, the Scottish Government (2032) and the UK Government (2040) have announced planned dates to end the sales of petrol and diesel vehicles. Hybrid vehicles would not be included. Norway (2025), India (2030) and France (2040) have also set targets, and the Netherlands (2025), Germany (2030) and China (tbc 2030) are proposing sales bans<sup>55</sup>. Electric and hybrid cars have a small but growing share of new car sales in Scotland. There was a 66% increase between 2016 Q3 and 2017 Q3. However, they are still a fraction of total sales. The total number of hybrids and electric vehicles sold in the UK in the first two months of this year was just over 5% of the total 56. This means that they are an even smaller proportion of vehicles presently on Scotland's roads.

Transport is also a significant contributor to air pollution, particularly road transport. Transport generates just over one-sixth of Scotland's total fine particulate matter and over one-third of the total emissions of nitrogen oxides. Emissions of nitrogen oxides from road transport are improving, "but not at the expected rate, considering the tightening of engine emission standards in recent years" 57. These have significant risks to public health, exacerbating other health problems, especially for the elderly and young, with deprived areas often worst affected.

Judgements by the High Court have demonstrated that government is legally obliged to tackle air pollution quickly and credibly. The UK Government has brought forward proposals for Clean Air Zones. These could include measures to encourage the uptake of ultra low emission vehicles, car clubs and active travel. There could be targeted investment to improve traffic flow, develop park and ride facilities and increase EV infrastructure, as well as

<sup>52</sup> Scottish Government (2017), Draft Scottish Energy Strategy: The Future of Energy in Scotland

<sup>53</sup> Scottish Government (2018), Scotland's Action on Climate Change

<sup>54</sup> Committee on Climate Change (2016), Reducing emissions in Scotland – 2016 progress report

<sup>55</sup> Green Alliance (2018), How the UK can lead the electric vehicle revolution

<sup>56</sup> https://www.smmt.co.uk/vehicle-data/

<sup>57</sup> Scottish Government (2015), Cleaner Air for Scotland – The Road to a Healthier Future

retrofit local bus, taxi or HGV engines. The Clean Air Zones could also include charging certain types of vehicles to enter or move within the zone<sup>58</sup>. A Clean Air Fund is making available £220m over 3 years<sup>59</sup>. London which already has a low emission zone based on its congestion charge, will introduce a toxicity Charge later this year and will expand the Ultra Low Emission Zone from 8 April 2019.

There are over 30 Air Quality Management Areas in Scotland. The Scottish Government is committed to working with local authorities to introduce Low Emissions Zones (LEZs) in Glasgow, Edinburgh, Aberdeen and Dundee by 2020 and into all other Air Quality Management Areas by 2023, where appraisals advocate mitigation. These will limit the access of vehicles that exceed emissions benchmarks, while permitting unrestricted access for low emission cars, vans and buses, as well as smaller goods vehicles relaying goods from consolidation centres. There is a total budget of £10.8m allocated to deliver LEZs. The Scottish Government is to work with the commercial and bus sectors, the Energy Saving Trust and the Low Carbon Vehicle Partnership to establish an Engine Retrofitting Centre in Scotland<sup>60</sup>.

Glasgow is to introduce Scotland's first LEZ by the end of 2018. Phase 1 will focus on bus movements through the city and the application for funding support to allow local bus fleet upgrade and retrofit. The inclusion of trucks, vans, cars, taxis,

and motorbikes will be phased in the period to 2022. Councillors have agreed to consider proposals for the introduction of a Road User Charging Scheme<sup>61</sup>.

The Commission supports the introduction of LEZs. However, it is concerned that there should be sufficient funding and lead-in time for bus operators and city centre businesses to upgrade their vehicles so that there is no reduction in services and, therefore, access, for example for the elderly, low income groups or disabled people.

The Scottish Government's target is that emissions in the transport sector will fall by 37% by 2032<sup>62</sup>. The Committee on Climate Change's central scenario for surface transport in Scotland is that emissions fall by 80% between 2014 and 2050, although they also state a high ambition scenario of over 90%63. The Scottish Government's target is that by 2050 Scotland "will be free from harmful tailpipe emissions from land transport<sup>64</sup>. The Committee on Climate Change has found that "additional policies will have to be put in place to accelerate uptake of low-carbon technologies and a greater reduction in demand for carbon intensive activities"65.

The Committee has called for continued investment in charging points and incentives to increase the market share of EVs and hydrogen systems in new cars, local measures to promote active travel and low-emission public transport, improved freight operations (including Urban Consolidation Centres and modal shift to rail) and measures to promote efficient driving (including Intelligent Transport Systems)<sup>66</sup>. Improving the level of active travel in our cities will also have wide social and economic benefits through improving people's health and wellbeing.

Action on climate change and air quality are also driving significant changes in demand for rail freight. The closure of coalfired power stations, such as Longannet and Cockenzie, has reduced the movement of coal by rail, a substantial part of the rail freight market with a "rapidity and severity...clearly beyond expectations"67. However, these environmental policies are also strong drivers to encourage modal shift from road haulage to rail freight. Per tonne of cargo rail freight produces 76% less carbon dioxide than road freight and rail freight emits less than one tenth of the nitrogen oxide and fine particulates of road haulage per tonne<sup>68</sup>.

The Commission supports the introduction of LEZs. However, it is concerned that there should be sufficient funding and lead-in time for bus operators and city centre businesses to upgrade their vehicles so that there is no reduction in services and, therefore, access.

- 58 Department for Environment, Food & Rural Affairs (July 2017), Air quality plan for nitrogen dioxide (NO2) in UK
- 59 Department for Environment, Food & Rural Affairs (March 2018), Clean Air Fund
- 60 Scottish Government (2018), Scotland's Action on Climate Change
- 61 https://www.glasgow.gov.uk/index.aspx?articleid=22339
- 62 Scottish Government (2018), Scotland's Action on Climate Change 63 Committee on Climate Change (2017), Advice on the new Scottish Climate Change Bill
- 64 Scottish Government (2018), Scotland's Action on Climate Change
- 65 Committee on Climate Change (2016), Reducing emissions in Scotland 2016 progress report
- 66 Committee on Climate Change (2016), Reducing emissions in Scotland 2016 progress report
- 67 Transport Scotland (2016), Delivering the Goods: Scotland's rail freight
- 68 Transport Scotland (2016), Delivering the Goods: Scotland's rail freight

### Reliability and Resilience

Unplanned closures of key road and rail infrastructure in recent years, such as the Lamington Viaduct on the West Coast Main Line and the Forth Road Bridge, and periods of disruption in transport services, have underscored the fact that people and businesses need and value reliability.

With climate change, extreme weather events are forecast to disrupt transport links more frequently. It has been estimated that 10% to 20% of roads and railways in Scotland have a significant likelihood of flooding<sup>69</sup>. The Committee on Climate Change found that progress is being made in assessing risks to road and rail and that investments are being made to renew critical assets and structures<sup>70</sup>.

While there are uncertainties about the rate, scale and effects of climate change, and the political, industry and consumer response, reducing transport's contribution to climate change and increasing the resilience of transport networks to flooding and landslides are likely to be ongoing priorities.

Unplanned closures of key road and rail infrastructure in recent years and periods of disruption in transport services, have underscored the fact that people and businesses need and value reliability.

Technology and the Personalisation of Services Technology and personalisation of services are driving disruptive changes in many sectors. This can be illustrated across a range of indicators, examples of which are highlighted below:

- Asset-light, idea intensive firms are creating a winner-takes-all dynamic, capturing a growing profit share (31% in the West from 17% in 1999), by offering consumers much greater choice and comparison tools, and digital platforms have intensified competition, radically reduced prices and disproportionately cut sectoral profits. Companies have increased digital investment partly by lower investment in physical infrastructure.
- The UK has one of the most advanced e-commerce markets in the world,

with approximately 15% of retail sales conducted online. There are approximately 40,000 fewer shops today than there were in 2006 and across the industry net profitability has fallen from 6 to 8% of sales pre-2007 to 3 to 5% today<sup>71</sup>. About 20% of online shopping currently takes place during commutes<sup>72</sup>.

- The number of people staying with an Airbnb host increased from about 47,000 in summer 2010 to almost 17m in summer 2015, a 353,000% increase, booking more rooms than the world's largest hotel chains<sup>73</sup>.
- Skype's revenues were \$2bn in 2013 but it reduced those of traditional telecoms companies by \$37bn<sup>74</sup>. Changes in the way people bank have led to the closure of 145 branches in Scotland in 18 months<sup>75</sup>.
- The digitalisation of production, for example 3D printing, means that it no longer has to be factory centralised and this could lead to consumer products being manufactured closer to their markets<sup>76</sup>.

Uber was founded in 2009 and is the first of the new transportation network companies. It has since grown very rapidly and is now available in hundreds of cities around the world, including Glasgow and Edinburgh. Competitors have since entered the market in various countries (for example Lyft in the US). The Uber platform leverages the technology available in modern smartphones to enable people to request a ride from a fully licensed private hire driver at the tap of a button. Real-time data and analytics are used to achieve very high levels of efficiency. More recent developments in some markets include options for dynamic car-sharing, parcel delivery, food delivery and CAVs.

### **Transport**

Market disruption has also been taking place in parts of the transport sector, most obviously in the growth of transportation network companies providing ride-hailing services in the

<sup>69</sup> Sayers, P. B. et al. (2015), Climate Change Risk Assessment 2017: Projections of future flood risk in the UK

<sup>70</sup> Committee on Climate Change (2016), Scottish Climate Change Adaption Programme: An independent assessment for the Scottish Parliament

<sup>71</sup> British Retail Consortium (2016), Retail 2020: Fewer But Better Jobs

<sup>72</sup> Deloitte (2016), The future of mobility: What's next?

<sup>73</sup> Airbnb (2015), Summer Travel Report: 2015

<sup>74</sup> McKinsey Global Institute (quoted in Fortune, 'Why every aspect of your business is about to change')

<sup>75</sup> BBC Scotland News (2016), Changing habits' force Scottish bank branch closures

<sup>76</sup> UK Government (2018), Made Smarter Review

taxi market. These use online platforms to connect paying passengers with drivers who provide the transportation in their own properly licensed vehicles. In addition, ride-pooling services, which use apps and data on travel patterns to put passengers going the same way together in the same car or an on-demand minibus, are being offered in more cities. It has also been forecast that the number of people who participate in car-sharing services, in which drivers can rent vehicles for when they need them, will increase from 5.8m to 35m worldwide in the next five years<sup>77</sup>.

In addition to shared mobility services, there has also been the growth of aggregators, who present transport and travel information in customer-friendly formats and who may come to remove the relationship with the customer from the legacy transport operator, of data-driven transport planning services, and of investments in CAVs. National and regional governments have responded to these changes in different ways – from restrictive to neutral to actively supportive in partnerships.

National and regional governments have responded to these changes in different ways – from restrictive to neutral to actively supportive in partnerships.

Online platforms have also been significantly changing the freight sector. It has been estimated that parcel volumes grew by almost 50% globally between 2014 and 2016, and are on track to increase at rates of 17-28% annually up to 2021<sup>78</sup>. Business-to-business deliveries have lost market share to business-toconsumer deliveries which have grown from 40% to over 50% in a number of markets<sup>79</sup>. Online shopping has helped to drive the increase in LGVs on the roads. Consumers also often order multiple similar items, pick one and return the rest because the returns are free or cheap. In the UK. 25% of women's fashion ordered online is returned and in Germany about 70% of items ordered online are returned<sup>80</sup>. This changing consumer behaviour increases traffic, congestion and emissions.

Online retailers which previously used delivery companies to deliver orders to customers have started to develop their own distribution networks<sup>81</sup>. The Royal Mail has said that this will more than halve the growth potential of its parcels business<sup>82</sup>. Transportation network companies are now connecting people who will pay for a parcel to be delivered with private drivers who are best placed to pick it up and deliver it<sup>83</sup>. With the last mile accounting for half of the cost of delivering a parcel and customer experience a key differentiator, new delivery models will be a focus for companies<sup>84</sup>.

Research by McKinsey has found that, while 70% of customers prefer the cheapest option of home delivery, almost

a quarter will pay significant premiums for same-day or instant delivery – with just over 30% of young consumers prepared to pay extra<sup>85</sup>.

Reports have suggested that significant increases in traffic congestion in London in the last few years have been caused by rapid growth in delivery vans due to online shopping and private hire vehicles, as well as by increased roadworks and a reduction in road space<sup>86</sup>.

# Smart, Integrated Planning and Payment Methods

Recognising that technology can better integrate multi-modal, multi-operator journeys, the Scottish Government is currently working with transport operators on the roll-out of smart ticketing across bus, rail, ferry, subway and tram networks. The ScotRail network is smart-ready and the five largest bus operators have introduced multi-operator smart ticketing in Aberdeen, Dundee, Glasgow and Edinburgh city regions.

There are many other new smart ticketing initiatives and technologies being developed. However, there is a need to be mindful of short-term political commitments to these which may soon rapidly lose market share and be overtaken by emerging technologies.

In London, contactless payment on entry and exit is gradually making the Oyster Card obsolete. Some bus

- 77 The Economist (October 1st 2016), Its starts with a single app
- 78 https://www.pitneybowes.com/us/shipping-and-mailing/case-studies/pitney-bowes-2017-parcel-shipping-index.html
- 79 McKinsey (2016), Parcel delivery: The future of the last mile
- 80 Financial Times, UK retailers count the cost of returns
- 81 USA Today (January 13th 2016), Amazon quietly builds its own shipping company
- 82 The Guardian (February 16th 2016), Delivery on demand: is Uber's courier service a threat to European operators?
- 83 The Guardian (February 16th 2016), Delivery on demand: is Uber's courier service a threat to European operators?
- 84 McKinsey (2016), Parcel delivery: The future of the last mile
- 85 McKinsey (2016), Parcel delivery: The future of the last mile
- 86 Begg, D (2016), The Impact of Congestion on Bus Passengers

operators in Scotland and the One-Ticket scheme for bus and rail travel in East Central Scotland utilise mobile phone ticketing. Contactless payments are now widely available in Scotland on First, Stagecoach, Citylink and McGills buses, whilst the big five bus operators in the UK have set a target to introduce contactless bus transactions across the UK by 2022. It has been estimated that this could improve bus journey times by up to 10% by halving dwell time at bus stops<sup>87</sup>. Professor David Begg has proposed that the bus industry should do everything possible to accelerate their introduction in 2020, at least in the large conurbations.

There are predictions that digital currencies will form the sole basis of digital transactions in the future<sup>88</sup>, although these currencies are yet to fully establish themselves as part of the mainstream. If in the future a transportation network company chose to offer payments via digital currencies this may force other providers to offer this method of payment.

The Commission believes that the Scottish Government should adopt a flexible, technology-neutral approach to the roll-out of smart, integrated planning and payment methods in the light of changes in the market, focusing on

The Commission believes that the Scottish Government should adopt a flexible, technologyneutral approach to the roll-out of smart, integrated planning and payment methods The development of MaaS both reflects and will enable a growing demand for journeys to become more personalised as lifestyles become more complex and work becomes more flexible and 'non-standard'.

outcomes and adaptability to enable the changing and growing demands from new technologies.

These will also generate significant data. Along with traffic management and travel information systems, this data should be used to measure the effectiveness of investments and derive deeper understanding of the demand for travel and the prevailing conditions experiences by traveller.

# Personalisation of Transport Services and the Evolution of MaaS

Expansion of customer focussed, smart. integrated planning and payment methods and the rapid growth of transportation network companies in global taxi markets could herald a shift across the transport sector from an operation-based to a service-based model. This aims to provide mobility for users' specific needs, whether passengers or goods, through a digital platform which creates options, manages and enables payment for journeys across public and private services as a single, integrated journey. The principle is seamless, doorto-door connectivity for all, based on consumer choices utilising established services such as trains and a range of on-demand services for taxis, cars and bikes and delivered through one account. These ecosystems are increasingly termed Mobility as a Service (MaaS).

The development of MaaS both reflects and will enable a growing demand for

journeys to become more personalised as lifestyles become more complex and work becomes more flexible and 'nonstandard'. A range of payment models and methods are being developed and tested in different cities and countries for multi-modal travel, such as pay-asyou-go and monthly subscriptions<sup>89</sup>.

Digital aggregators will be at the centre of this model, building and managing the marketplace (e.g. offering dynamic pricing to attract customers and manage demand) while capturing a large share of the profits.

There are significant barriers to the full delivery of MaaS in Scotland, including transport and digital infrastructure capability, the diversity of the transport sector and variety of legislation, regulation and funding models. However, there is no doubt that MaaS is coming and presents a very significant opportunity for companies and the public sector in Scotland; although there is still uncertainty about how and when the market will be realised and how the potential benefits will be delivered on a replicable and widespread basis.

When MaaS is delivered, the benefits for consumers could include personalised, more reliable, faster, affordable, and less stressful journeys. The perceived need to own a car or two may no longer be the case for many due to on-demand, shared

<sup>88</sup> Trautman, L. (2016) Is Disruptive Blockchain Technology the Future of Financial Services?

<sup>89</sup> The Economist (October 1st 2016), Its starts with a single app

# **Future Mobility Stories - Jane's Commute**

Turning off the alarm on her smart phone, Jane is informed by her Mobility App of any delays on her preferred routes to work. After working from home yesterday morning and going in later, she is scheduled to be in the office earlier today. It's a relief that all the city's systems are working well and she decides to follow the recommendation based on her usual preference for an early start in wet weather of the fastest route available based on real-time information – this will be ride-sharing an EV with neighbours who are also travelling to the station. Selecting this journey, she receives reward points for lower carbon emissions.

Over breakfast Jane and other parents connect through a specific Mobility App to arrange a ride-share to take their children to school. She is then picked up with her neighbours and taken to the station, the fare is divided amongst their accounts using the app. Walking into the station she collects a coffee she pre-ordered and paid for on the way in the ride-share car through her app points and she places her smartphone on the barrier which lets her through. The superfast Wi-Fi in the station allows Jane to check the app which informs her where best to stand on the platform to get a seat on this train. While onboard and checking her emails, she's continually alerted to any changes in her journey and gets recommendations on her journeys to and from meetings, booking a company club car. Unfortunately, there's an incident at a station. Jane and her fellow passengers are instantly alerted by their smartphones of the potential delay. Using the data generated on their journeys, services respond

quickly to current traveller needs. Jane is given options of how she can still get to work on time. She's in a rush so she quickly orders a CAV which will be ready for her at the next station, trading in some points to request priority.

At lunchtime, she and her colleagues group together to order lunch and the app provides them with information of all the local possible food options with their choices delivered by an AV.

After lunch, she receives a message telling her which car to collect and where it is parked. It's an AV and her smartphone immediately connects with the car's system, allowing her to check her presentation on the screen inside the car's front window. She can focus fully on it in the knowledge that the AV's integrated communication and sensory systems will take her to the meeting safely and as quickly as possible.

By the end of the day, the weather has improved. Jane selects the exercise option on her Mobility App and is informed that by using the local bike hire scheme outside her office she can use the dedicated bike lane to get to the station 10 minutes quicker, allowing her to catch an earlier train. Jane pre-hires a bike and is given double reward points for active and low carbon travel. On the train home, she checks deals from her local supermarket and realises that if she buys her shopping now she can use some of her points, save half the price and get it delivered within the next hour, so that her partner can make dinner.

services. Operators may be able to respond to and manage demand in a much more flexible, efficient and environmentally-friendly way. Capacity could be utilised more effectively and congestion reduced, with fiscal, economic, social and environmental benefits. The impacts on socially necessary bus services, often subsidised by local government, are not yet clear.

An important challenge will be the approach to be used to measure success.

This will be important whether the public or private sector operates the services. Consideration should be given to the definition of a service level agreement for MaaS.

However, there could be positive or negative effects on cities and regions. Competition from car-sharing services in cities may mean that some conventional public transport services, such as buses, may be challenged. This may increase congestion in cities and

place added pressures on marginal city and rural bus services, where many bus services are already struggling and under threat and car-sharing services may not be available. Alternatively, there is potential that increased levels of on-demand technology could improve the responsiveness and efficiency of public transport provision in rural areas, and the "Dial M for Moray" service provides an early example of how this could develop. A further concern is that

a winner-takes-all dynamic among transportation network companies may eliminate competition and dynamic pricing could disadvantage the poorer in society. This is one reason why government needs to be involved in shaping the future of mobility and connectivity. Choice could be reduced for some users or increased. Access to opportunities, public services and amenities may decline or improve for them. At this stage we do not know. MaaS potentially offers the ability to reduce demand through car sharing, reduce costs and improve efficiencies and help achieve social equity and environmental goals for our communities. Scottish-based companies could also benefit through access to new markets and the development of new services and products. These possibilities should be researched as part of the update of Scotland's National Transport Strategy.

The impact of MaaS is also potentially significant beyond transport. Options are now being offered to users, linking lifestyles to personalised journeys – for example anticipating where and how people may want to travel based on their calendars, where their friends are

A winner-takesall dynamic among transportation network companies may eliminate competition and dynamic pricing could disadvantage the poorer in society.

going or new places to eat<sup>90</sup>. As MaaS develops, profits may not primarily be derived from the transport services themselves - which could even be provided at low or no cost – but rather from additional services which could be sold to users. This will drive change and partnerships in the wider private sector to make the most of the gains, support wider community objectives and protect business.

### Digital Connectivity and Access to Data

Digital connectivity and access to data are essential to the delivery of MaaS. Smart mobiles will enable the creation and choice of personalised journey options and provide real time information to users and operators based on the sharing of locations and the aggregation of data from users and smart networks.

However, critically, the digital connectivity to integrate services reliably and allow the widespread provision of MaaS is not yet available. England and Northern Ireland receive 4G coverage across 60% of their landmass compared to just 17% in Scotland in June 2017 (up from 6% the previous year)91.

# Digital connectivity and access to data are essential to the delivery of MaaS.

Many A and B roads in Scotland are under-served and lack adequate voice and data coverage compared to other nations in the UK<sup>92</sup>. The comparison is not as stark regarding motorways, which in Scotland are concentrated in the Central Belt. which underlines that coverage is poorest in the north and south of Scotland, especially in rural areas.

Access to data would appear to be a key to unlocking opportunities and addressing any possible threats. However, data collection and management costs money and use still needs to be made of this data through analytics. Potentially, basic data could be made available for free, while more added value data could be obtained for a fee. This monetisation would support stewardship of data, while enabling the private sector to develop new markets related to data analytics.

This would encourage and enable companies to respond flexibly to

Geographic coverage from all mobile operators	A & B Roads, % road network		Motorways, % road network	
	Telephone Calls	Data coverage	Telephone Calls	Data coverage
UK	68%	58%	97%	91%
England	78%	66%	97%	91%
Northern Ireland	62%	54%	91%	81%
Scotland	46%	38%	96%	88%
Wales	53%	41%	99%	96%

<sup>90</sup> Financial Times (November 2nd, 2016), Uber adds lifestyle tracking to ride-hailing app

<sup>91</sup> Ofcom (2017), Connected Nations 2017 92 Ofcom (2017), Connected Nations 2017

demand and enter into partnerships which would deliver seamless, door-to-door journeys. In cities, it would help to maintain a competitive marketplace and reduce barriers for new entrants. In rural areas, it would inform dialogue between operators and funders about the most efficient way to maintain socioeconomically important services – which may involve one or more of scheduled or on-demand bus or car-sharing services.

The Scottish Government is proposing to require the operators of local bus services to release data on routes, timetables, punctuality and fares<sup>93</sup>. Most bus operators already release data via Traveline Scotland.

London and Glasgow are currently developing open data on every possible route available to cyclists in the city, giving people more choice and further encouraging the increase in active travel within the city.

Building in a data evaluation mechanism into such a data exchange would help to generate both a public and a private value for the data. It is vital that data continues to be stored and made available to enable analytics to be conducted and added value created.

There is very clearly a need for a public conversation about data governance to inform the development of policies and

Access to data would appear to be a key to unlocking opportunities and addressing any possible threats.

Copenhagen and Hitachi have introduced a City Data Exchange. The data exchange will, through new types of data from various sources, provide insight into how the city functions and thereby ensure better planning and solutions for the city and its citizens. It combines free and priced data from the public and private sector. Hitachi has co-created this solution with more than 700 companies, cities and organisations to ensure that the solution matches the demand of those who want to access and use data. It is an integral part of the Copenhagen Smart City Strategy and its aim to become Carbon Neutral and create growth at the same time. Companies request data for the purpose of making more innovative city solutions and services for the citizens.

plans. This will help to address questions of "who owns the data; who is entitled to access and use it; what are the terms for sharing it; what security measures need to be adopted to keep it safe?" 1. In addition, who ensures that it is accurate and updated?

One of the key challenges is that the successful roll out of MaaS and CAV and the operational efficiency and customer centric service benefits it could bring, can only be achieved through the use and sharing of data. However, personal privacy and safety needs to be protected - the introduction of EU General Data Protection Rights ("GDPR") in May 2018 reflected the growing complexity and regulation in this area. The UK Government's Data Protection Bill will implement GDPR in the UK. A balance will need to be struck. This public conversation should seek to address and allay concerns about openness, ownership and security.

Government will also need to consider legislation and regulation to unlock the opportunities, for example competition law, rail franchise contracts and bus subsidies, so that in response to the data, operators' services can be changed

There is very clearly a need for a public conversation about data governance to inform the development of policies and plans.

or they can enter into public-private partnerships to meet users' needs.

With MaaS in prospect, cities and countries are beginning to compete to develop and test models<sup>95</sup>. Some countries and regions are already developing their approaches. Finland<sup>96</sup> has revised legislation covering different transport modes to bring them into harmony and has passed legislation requiring anyone working in mobility to open up their data and APIs, Similar moves are happening in several US states<sup>97</sup>.

Those who are successful may be able to gain a competitive edge as places to live and work, invest in and visit. The Commission recommends that the Scottish Government and industry should urgently give consideration to the development of MaaS in Scotland.

<sup>93</sup> Transport Scotland (2017), Local bus services in Scotland – improving the framework for delivery

<sup>94</sup> Pinsent Masons (2016), Connected and Autonomous Vehicles: The emerging legal challenges

<sup>95</sup> The Economist (October 1st 2016), Its starts with a single app

<sup>96</sup> The Economist (October 1st 2016), Its starts with a single app

<sup>97</sup> Deloitte (2016), The future of mobility: What's next?

# **Future Mobility Stories - Holidays in Scotland**

Justin and his family are on their way from Canada for the holiday of a lifetime in Scotland. Along with booking their flights on a mobility app, they have purchased a multi-modal bundle of public transport, ride-hailing, car-sharing and active travel, and pre-planned journeys and purchased tickets for some journeys, which are stored on a smart phone for use. Landing at Glasgow Airport, they download a "My Scotland" app which will serve as a single access point to information and MaaS. They are informed where to go for the new tram-train service to Glasgow city centre. Connecting to the superfast Wi-Fi on board, Justin is offered further advice and information on the best places to visit in the next few days.

The family decide to include a highly-recommended show at the Edinburgh Festival into their plans. They use the app to crowd source information on travel options and check feedback from fellow travellers, then book seats on the train from Glasgow to Edinburgh and back, receiving a discount because of their previous train journey, and their reservations for the theatre and dinner at a partner restaurant.

Later in the week, the highlight of their visit is a few days in the Highlands. Justin had taken the same journey a few years before and is impressed that the trains are now far more comfortable intercity services and that the journey is noticeably quicker. While they spend most of their time admiring the scenery and using an augmented reality application that highlights the landmarks on their journey, there's just enough time to use the superfast Wi-Fi to check again what's on in the region.

They agree on a cycling trip to Loch Ness. As it is the peak season, demand for bikes is high and it is reassuring to know that there is real-time monitoring of demand to ensure that no-one will go without. Justin also persuades the family to let him go on a distillery tour for a few hours. He wants to have a few drinks, so he books an AV with a local mobility provider and also pays to watch the Ottowa Senators latest game on the screen inside the car's front window on the way back to their rented accommodation. Booking through the app allows all their tickets and any other journeys to be held on one device under one account. The family will be able pick up their bikes by scanning his smartphone on the locks.

At the end of a whirlwind few days, the family are exhausted as they try to cram in as much as possible. However their smartphone reminds them of their options, with the last trains back to Glasgow leaving at 8pm and 9pm.

# Supply

### Technology

# From the 'Digital Road Network' and Connected Cars to Autonomous Vehicles (AVs)

Both cars and road networks are becoming increasingly digitalised. 'Connected cars', with access to the Internet and numerous sensors, which are aware of their physical surroundings, can communicate with other vehicles and infrastructure, and have function-specific automation (e.g. better cruise control and automated parking). These are likely to proliferate from the late 2010s.

Highways England has plans for Smart Motorways which will use active traffic management techniques such as variable speed limits and (selective) hard shoulder running at busy times, radar technologies to immediately detect and report vehicles that have broken down, and wireless transmission of real-time journey information and advice directly to vehicle occupants. A trial is planned with specially adapted vehicles on the A2/M2. This will help to manage demand and reduce congestion, maximising the efficiency of road capacity. Overhead gantries could be removed, reducing costs and improving the landscape. It also plans to trial connected vehicles in which vehicle-to-vehicle communication allows for platooning of vehicles travelling very closely but safely together at a high, constant speed to maximise use of road capacity, increase fuel efficiency and improve safety<sup>98</sup>. Transport Scotland is planning to install new Intelligent Transport Systems as existing systems reach the end of their lives and as the A9 (already referred to as a proposed "Electric Highway") and A96 dualling programmes are constructed. Digital

connectivity and renewable energy will be key to the rollout across trunk roads<sup>99</sup>.

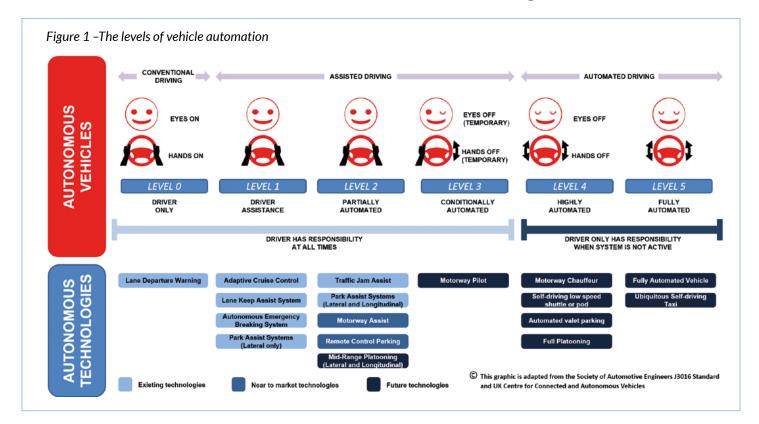
The Netherlands plan for 'smart highways' includes lanes that can recognise and then recharge electric cars, glow-in-the-dark road surfaces and cycle lanes, interactive 'use when needed' road lighting, and road signs that automatically respond to specific traffic situations<sup>100</sup>.

The development of 'connected cars' and 'connected highways' – along with MaaS – anticipates even more fundamental changes. In particular, leading carmakers and technology companies are pursuing the development of AVs with a view to mass production.

There is a high degree of uncertainty about the speed and scale of this change. Levels of automation are defined in six levels from L0 to L5<sup>101</sup>.

L2 capability (partial automation) is increasingly common. The 2019 Audi A8 is set to introduce an L3 driving system. This biggest gap in capabilities is between L3 and L4 (high automation). L4 road vehicles may be available within 5 years. There is a particular uncertainty about L5 (full automation) in which no driver is required. Companies such as Google are focusing on L5 and it is possible that cars with these capabilities will be available within 10 years and widely available from 2030, although others doubt they will ever be feasible.

The development of 'connected cars' and 'connected highways' – along with MaaS – anticipates even more fundamental changes. In particular, leading carmakers and technology companies are pursuing the development of AVs with a view to mass production.



<sup>99</sup> Transport Scotland (2017), Future intelligent transport systems strategy 100 Atos (2016), Digital Vision for Wales

<sup>101</sup> House of Lords Science and Technology Committee, 2nd Report of Session 2016-17, Connected and Autonomous Vehicles: The future?

There are concerns over issues such as safety, liability, security, privacy, cost and regulation<sup>102</sup>. The UK Government's Automated and Electric Vehicles Bill will make provision for the registration of all driverless cars in the UK, and addresses how liability for accidents involving such vehicles should be apportioned<sup>103</sup>. It has asked the Law Commission and the Scottish Law Commission to undertake a three-year review of the UK's legal framework for CAVs, including issues such as road traffic legislation, product liability, public transport networks and ondemand passenger services<sup>104</sup>. There are major technological challenges and digital infrastructure would need to be in place to ensure reliable connectivity. However, a number of recent studies<sup>105</sup> have projected more rapid and increased uptake. Fully autonomous vehicles could make up over 10% of global sales in 2035<sup>106</sup>. The use of CAVs for first and last mile applications could be an early implementation.

To enable their adoption in Scotland very significant investment will need to be made above and beyond the existing Digital Scotland programmes to improve digital connectivity. Part of the electromagnetic spectrum will need to be allotted to connected vehicles, which may mean measures to make more of the spectrum available, such as the liberalisation of "white space" 107.

The consequences of these changes are also uncertain and the subject of different projections. The medium-term, at which time there is a mixed fleet, is especially

difficult to forecast. The challenges of the transition from general, private ownership to shared CAVs are likely to be significant. An OECD report found that mixed fleets scenarios of shared CAVs and privately-owned cars significantly increase total vehicle travel, with much smaller reductions (or, with no shared CAVs and no high capacity public transport, even a small increase) in parking space requirements<sup>108</sup>. A report by Atkins suggested that the likely tipping point for the proportion of CAVs to produce major traffic flow benefits may be between 50% and 75%<sup>109</sup>.

Some recent reports have highlighted that the growth of CAVs could reduce personal car ownership but significantly increase utilisation of shared vehicles and road demand, for example by

enabling car use by those currently unable to drive<sup>110</sup>. Much would depend on whether car ownership is largely replaced by on-demand car-sharing and on the availability and take-up of public transport and active travel. The OECD report presented a range of scenarios as presented in the table below:

In summary, the OECD report suggested that shared fleets of CAVs with high-capacity public transport could deliver the same mobility with 10% of the vehicles in a mid-sized European city. If cars, taxis and buses are replaced this would lead to 6% more car-kilometres travelled. However, in cities with low-capacity public transport there would be an 89% increase in car-kilometres travelled<sup>111</sup>.

Change in total vehicle traffic	CAVs	CAVs	CAVs	CAVs
	<ul> <li>not shared</li> <li>without high- capacity public transport</li> </ul>	<ul><li>shared</li><li>without high- capacity public transport</li></ul>	<ul> <li>not shared</li> <li>with         high-         capacity         public         transport</li> </ul>	<ul><li>shared</li><li>with high- capacity public transport</li></ul>
Fleet size	-77%	-87%	-83%	-90%
Weekday travel volumes (24 hours)	+89%	+22%	+44%	+6%
Peak hour travel volumes	+103%	+25%	+55%	+9%
Number of cars travelling during morning peak	-23%	-57%	-43%	-65%
Maximum number of parked vehicles	-84%	-93%	-89%	-94%

<sup>102</sup> Pinsent Masons (2016), Connected and Autonomous Vehicles: The emerging legal challenges

<sup>103</sup> https://publications.parliament.uk/pa/bills/cbill/2017-2019/0112/cbill\_2017-20190112\_en\_1.htm

<sup>104</sup> https://www.lawcom.gov.uk/project/automated-vehicles/

<sup>105</sup> RAND Corporation (2016), Autonomous Vehicle Technology: A Guide for Policymakers; Boston Consulting Group (2016), Self-Driving Vehicles, Robo-Taxis and the Urban Mobility Revolution etc

<sup>106</sup> IHS Automotive (2016), IHS Clarifies Autonomous Vehicle Sales Forecast – Expects 21 Million Sales Globally in the Year 2035 and Nearly 76 Million Sold Globally Through 2035

<sup>107</sup> Pinsent Masons (2016), Connected and Autonomous Vehicles: The emerging legal challenges

<sup>108</sup> OECD (2015), Urban Mobility System Upgrade: How Shared Self-driving Cars Could Change City Traffic

<sup>109</sup> Atkins (2017), Research on the Impacts of Connected and Autonomous Vehicles (CAV) on Traffic Flow

<sup>110</sup> AECOM; Smithson Hill (SE Cluster)

<sup>111</sup> OECD (2015), Urban Mobility System Upgrade: How Shared Self-driving Cars Could Change City Traffic

To enable (CAV) adoption in Scotland very significant investment will need to be made above and beyond the existing Digital Scotland programmes to improve digital connectivity.

A KPMG report concluded that CAVs will lead to more than 1 trillion additional people miles travelled and up to 4 trillion additional vehicle miles travelled, in the US alone, by 2050 112.

The availability of CAVs might encourage and enable more journeys by car rather than active travel. The costs of roads maintenance due to increased traffic and vehicle platooning could be higher.

Cyber-security of personal and business data, CAVs, and infrastructure networks will be essential to safeguard people from the threat of crime or terrorism.

However, CAVs could also offer key benefits. The recent *Travel in Britain in* 2035<sup>113</sup> report discusses the potential reduction in the frequency of crashes due to human error; enabling vehicles to 'platoon' closely together or travel at higher speeds or to drop off an occupant at a destination and park at a distance. CAVs could also improve accessibility of road travel to the elderly, underage, disabled, intoxicated or otherwise impaired. However, these socially inclusive benefits would only be delivered from full automation (L5)

and challenges, such as affordability and ability to access the vehicle without help, would need to be overcome<sup>114</sup>.

With the average person spending the equivalent of six working weeks a year driving<sup>115</sup>, CAVs could increase productivity by enabling more people to work while travelling. CAVs may become the "fifth screen" in people's lives (after cinemas, TV, computers and smart phones) selling a range of in-vehicle services, such as online shopping, food, films and programmes<sup>116</sup>.

Vehicle efficiency could be significantly improved by enabling utilisation throughout the day rather than cars being parked at home or a workplace for 95% of the time<sup>117</sup>. They also generate other potential ownership models, for example peer to peer car sharing so CAVs may be rented to other users by car owners at times when they do not need them, generating income for them.

### Freight

The growth in cities and in e-commerce is likely to continue to increase the quantity of goods being moved and delivered in and between cities. The economic success of urban centres depends on enabling these movements

in ways which reduce the potential negative economic, social and environmental impacts of congestion, emissions and noise.

This is likely to involve the use of technologies to consolidate loads at consolidation centres and on shared freight services, and to route and schedule deliveries to minimise traffic, and the introduction of fleets of electric LGVs for this purpose. A MaaS approach to these freight movements would involve a brokerage between service providers and those requiring a service.

The challenges it has in offering door-to-door services has, generally, restricted modal shift to rail freight to larger, longer-distance movements. Transport Scotland and train operators are currently considering opportunities for moving low bulk goods and parcels on passenger services<sup>118</sup>. In England, passenger trains are carrying high-value medical supplies from the East Midlands to London and fresh produce from Cornwall to restaurants in London. Innovate UK has recently awarded funding for a carriage design that can quickly switch from carrying passengers to carrying goods<sup>119</sup>.

Transport Scotland and train operators are also considering the potential for an 'urban freight network', to deliver goods to and between the centre of cities and large towns and remove retail waste products<sup>120</sup>.

<sup>112</sup> KPMG (2015), The clockspeed dilemma: What does it mean for automotive innovation?

 $<sup>113\ \ \, \</sup>textit{Travel in Britain in 2035: Future scenarios and their implications for technology innovation, 2016, prepared by RAND Europe for Innovate UK}$ 

<sup>114</sup> House of Lords Science and Technology Committee, 2nd Report of Session 2016-17, Connected and Autonomous Vehicles: The future?

<sup>115</sup> Pinsent Masons (2016), Connected and Autonomous Vehicles: The emerging legal challenges

<sup>116</sup> PwC (2016), Connected car report 2016: Opportunities, risk and turmoil on the road to autonomous vehicles

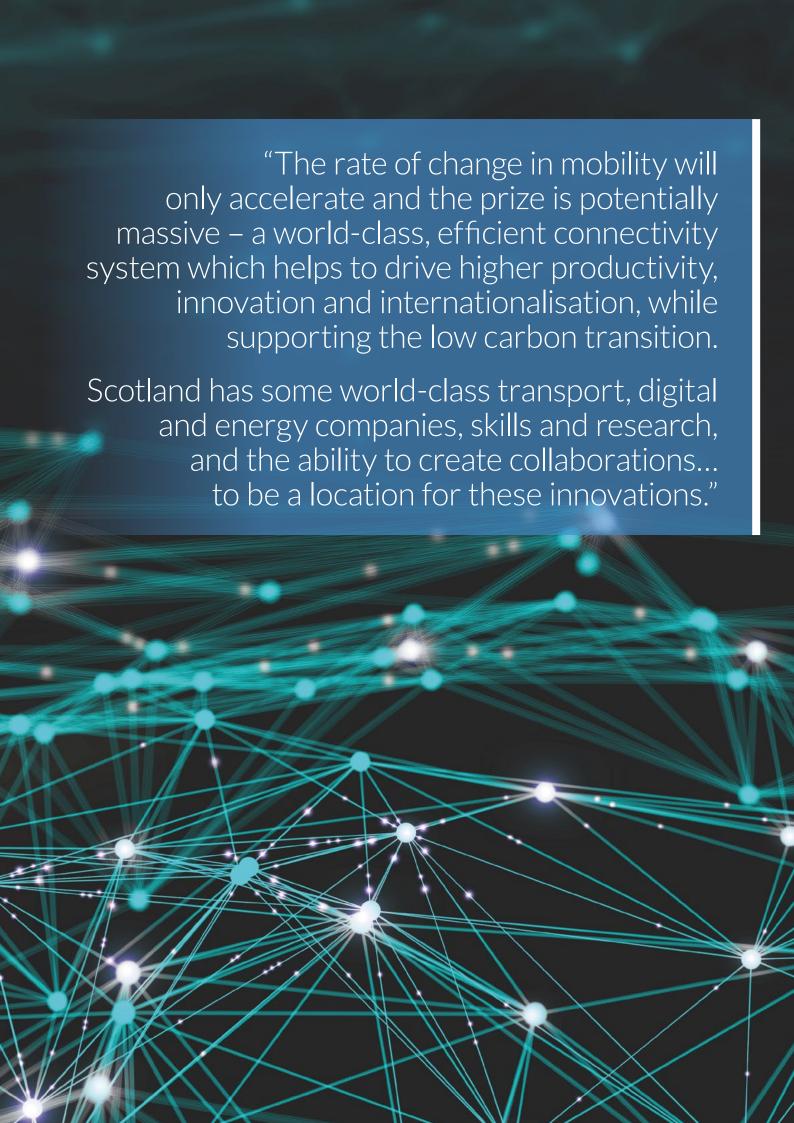
<sup>117</sup> RAC Foundation (2012), Spaced Out: Perspectives on parking policy

<sup>118</sup> Transport Scotland (2016), Delivering the Goods: Scotland's rail freight

<sup>119</sup> https://www.gov.uk/government/news/future-railways-36-million-invested-in-rail-improvements

<sup>120</sup> Transport Scotland (2016), Delivering the Goods: Scotland's rail freight





The Commission welcomes actions to support innovation and investment in rail freight. These should include a business development role for Network Rail (rather than just a facilitation role) and pump-priming of initial train services. This needs to be supported by joinedup public and private investment in and more streamlined delivery and operation of strategic rail routes, rail terminal and 'last-mile' rail and road infrastructure. The Commission believes that there are opportunities for freight on passenger services, especially as ScotRail specifies and introduces new and refurbished passenger trains and hopes that these will be progressed.

CAVs also have the potential to improve the efficiency of other modes of transport with several vehicles controlled by a fleet manager rather than by individual drivers.

McKinsey has recently forecast that CAVs – either lorries or vans with parcel lockers which travel on the roads to customers' homes, or droids which travel there on pavements or drones which fly there – will ultimately deliver nearly 100% of items to consumers and 80% of all items. It suggests that CAVs with parcel lockers will dominate regular, same-day and time window deliveries to homes in urban areas, with drones delivering

all same-day and time-window smaller parcels to homes in rural areas. McKinsey believes that bikes will remain the best delivery form for instant delivery in urban areas. The current model of delivery by a dedicated delivery person would continue to account for 20% of items, especially business-to-business and e-grocery<sup>121</sup>.

McKinsey believes that these changes will start to happen over the next decade in the developed world, with the earliest adoptions in places where labour costs are high enough to make the return on investment significant, regulations are adapted to support it and there is a favourable public acceptability<sup>122</sup>.

#### Cities

Cities will experience the effects of developments in CAVs for passengers and deliveries first and more directly and intensely. These effects are uncertain and potentially variable from city to city. Congestion may significantly increase or decrease. Population growth in cities may be further encouraged or – with longer commutes possible for more people – there may be a reversal in densification, with higher suburban and commuter town growth. Labour markets may expand. There are many questions that can only be answered by the private sector and government partnering to

test and monitor MaaS systems seeking to maximise the beneficial potential across the country.

Shared fleets of CAVs may enable the removal of all on-street parking and up to 80% of off-street parking, releasing significant swathes of valuable land for large-scale redevelopment and reengineering of city centres to further increase economic vibrancy<sup>123</sup>. This could be combined with other projects to assemble an even more transformational regeneration. Resilience is increasingly being interpreted to include social and community resilience as well as physical infrastructure resilience<sup>124</sup>. In Glasgow, for example, there has long been aspirations to bridge over the M8 and railway cuttings in the city centre with green space to reduce community severance and improve quality of life, and to redesign and re-designate traffic use of Sauchiehall Street to shared space. The latter is the first of 16 'Avenues' planned for the city centre, funded through the Glasgow City Region Deal, which will redistribute and share street space, including from vehicles to cycling and walking<sup>125</sup>.

Consideration needs to be given to the infrastructure which would be required to integrate CAVs with other transport services. For example, there could be a need to provide an increased number of conveniently-located drop-off and pick-up parking lanes or bays in or around transport terminals and stations.

Given the timescales involved in city centre redevelopment of typically over 10 years, the earlier planning takes place

The Commission welcomes actions to support innovation and investment in rail freight. These should include a business development role for Network Rail (rather than just a facilitation role) and pump-priming of initial train services.

<sup>121</sup> McKinsey (2016), Parcel delivery: The future of the last mile

<sup>122</sup> McKinsey (2016), Parcel delivery: The future of the last mile

<sup>123</sup> OECD (2015), Urban Mobility System Upgrade: How Shared Self-driving Cars Could Change City Traffic

<sup>124</sup> Resilient Glasgow (2016), Our Resilient Glasgow: A City Strategy

<sup>125</sup> https://www.glasgowlive.co.uk/news/glasgow-news/work-begins-72m-sauchiehall-street-14129481

for transformational changes to land use the better. However, the uncertainties around the development of the market make this difficult.

Industry is currently powering ahead with the development of CAVs, but, given the economic, social and environmental interest, the Commission believes that the UK and Scottish governments urgently need to review the issues and the digital capability necessary, and will need to play a more active role in shaping the market positively.

#### The Digital Railway

Rail networks are also becoming increasingly digitalised globally. Modern systems have utilised advance technologies, such as automation, to enable high-speed operation and increased frequency and capacity. For example, the Shinkansen railway in Japan safely operates with a minimum headway of 3 minutes between trains. But digital technologies are also being rolled-out to full national networks. Denmark plans to progressively deploy a digital railway solution across its entire network by 2023<sup>126</sup>.

In the UK, the doubling of passenger numbers in the last 20 years, serious lack of capacity on parts of the existing network and projection of a 'dramatic' increase in demand in the long-term has created a 'capacity crunch'. Network Rail has concluded that while conventional upgrades are vital, they "can't deliver the major increase in capacity the UK needs without costing too much, disrupting too much, and taking too long" 127.

## Future Mobility Stories - A Package from India

John wants to be among the first to use the latest smart watch made in India. Tracking of trends and customer preferences has predicted that there will be a high demand for the product in Scotland and based on these figures retailers have placed a large number of orders in advance of its release.

Entering the UK via a port, the goods are efficiently handled as the orders service is connected with HM Customs & Excise which has already processed the information, and there is a new free trade agreement.

Freight companies are also ready because the details have been shared with them in advance through a digital platform, allowing for streamlined transfer of the products to a mix of electric freight trains and recently-introduced driverless, hydrogen and electric HGVs, improving reliability and reducing costs at every stage. They are then sorted in largely automated consolidation centres distributed across the country – especially close to consumers in those areas of highest demand – until the release date.

The market is dominated by companies which have the distribution networks, digital infrastructure and skills to manage the volume and flow of parcels and the new technologies as efficiently as possible.

As he is a regular customer, the app can work out options to deliver the package to John based on his preferences. CAVs with parcel shelves are his habitual choice for regular, same-day and time-window deliveries – costs are lower due to reduced labour costs, they can operate 24/7 increasing the convenience of deliveries, and they are reliable because real-time information is constantly communicated to optimise the routes. He still uses delivery people for his weekly shopping – loading and unloading lots of parcel lockers takes too long, and it is good to have some help carrying the bags upstairs with his bad back. As John lives in the city, the lack of landing sites makes a drone impractical, but he has used them for same day delivery of smaller parcels when visiting his parents in the country. It was surprisingly cheap.

John cannot wait to get his hands on his new watch, so he selects the fastest possible option. His app offers him the option of a pick-up spot in the station on his way to work and he knows that it would inform the courier service and a locker access code would be sent to John's smartphone. But he wants this delivery into his hands. So, he opts to book a shared car which will deliver his new watch and then take him to work.

Network Rail's 'Digital Railway' programme<sup>128</sup> includes a number of related elements to accelerate the use of modern technologies. These include traffic management systems, train control systems, a connected driver advisory system and automatic train operation. Network Rail has been developing five route-wide business cases. The Chancellor of the Exchequer announced from the National Productivity Improvement Fund £450m in 2016 to trial new digital rail signalling technology and £84m in 2017 for in-cab digital signalling.

Key to the potential long-term transformation of the railway is the introduction of a new traffic management system to ensure that the network responds better to disruption by managing capacity in real-time and the progressive modernisation of signalling across the network, which would allow routes to operate much more flexibly and accommodate more passenger and freight paths. Network Rail has been testing the application of the cab signalling component, the European Train Control System (ETCS). There have been concerns about a lack of discussions with rail freight operators, who have tight margins, about cab fitments<sup>129</sup>.

Network Rail has said that its investment programme between 2019 and 2025 "is expected to mark a turning point for digital deployment as digital railwayready infrastructure combines with more fitted trains and the rollout of digital train control, traffic management and

connected driver advisory systems."130 The rail industry has jointly proposed to the UK Government that digital train control and traffic management systems can be rolled out at lower cost than conventional signalling by 2025 as part of an Industrial Strategy 'sector deal'131.

In Network Rail's strategic plan for investment in Scotland between 2019 and 2025 there are currently no planned digital railway interventions, but it is working to understand whether there may be a business case for a traffic management intervention aligned with the planned control system renewal at Edinburgh<sup>132</sup>.

In Network Rail's strategic plan for investment in Scotland between 2019 and 2025 there are currently no planned digital railway interventions.

ETCS Level 3, which would replace all track-side signals and train detection equipment with equipment on-board the train, is also in development. Network Rail has projected that, for some routes, it could, in conjunction with a traffic management system, deliver up to 40% more trains per hour at a 30% lower cost than conventional line construction by allowing trains to run closer together. Removal of this track-side infrastructure would also cut the costs of maintenance. These levels of projected benefits have been challenged as overestimated by some others in the rail industry.

Other parts of the Digital Railway include the use of modern technology in demand management, smarter ticketing options and travel information, asset management, stations and freight.

Network Rail proposes to adopt modern digital signalling and train control within the next 25 years. It is recognised that there will need to be a cross-industry approach to investment. The Commission supports the roll-out of the Digital Railway and call for government and industry to work closely together to develop a strategic plan in Scotland.

#### Electric and Hydrogen Vehicles

The Committee on Climate Change's assessment is that "the global outlook for EVs is looking increasingly positive, with battery costs falling more rapidly than previously anticipated and several governments and automotive manufacturers making public commitments to accelerate uptake". 133 Battery costs have fallen by 65% since 2010 134.

There are now over 600 publicly available charge points in Scotland, with over 1,200 charging bays, and over 40 private charge points. Over 150 rapid-charge points have been installed at 50-mile intervals on Scotland's primary road network. Dundee has the UK's "most extensive" urban rapid-charge network and one of the UK's largest electric taxi fleets.

Hydrogen fuel cells combine compressed hydrogen with oxygen to produce electricity. Hydrogen vehicles can be refuelled in 3 to 5 minutes using a pump

<sup>128</sup> Network Rail (2018), Digital Railway Programme Strategic Plan

<sup>129</sup> UK Parliament Transport Committee (2016), Rail technology: signalling and traffic management inquiry

<sup>130</sup> Network Rail (2018), Digital Railway Programme Strategic Plan

<sup>131</sup> Network Rail (2018), Route Business Scotland Route Strategic Plan

<sup>132</sup> Network Rail (2018), Route Business Scotland Route Strategic Plan

<sup>133</sup> Committee on Climate Change (2016), Reducing emissions in Scotland – 2016 progress report

<sup>134</sup> https://www.bloomberg.com/news/articles/2016-10-11/battery-cost-plunge-seen-changing-automakers-most-in-100-years

and have a range of around 300 miles per tank, like conventional vehicles, far greater than current EVs. Hydrogen can be created from renewable energy sources and it can also be used for heating and power.

The Aberdeen Hydrogen Bus Project has set up a collaborative partnership with industry and public sector organisations to fund Europe's largest demonstration of hydrogen fuel cell buses. The city has a fleet of hydrogen-fuelled vehicles, including buses, light vans and cars, which will be made available to the public through a car club<sup>135</sup>.

The H2Mobility coalition has planned an initial network of about 56 hydrogen refuelling stations across the UK by 2020 to provide basic national coverage<sup>136</sup>.

Car manufacturers and industry experts expect that, with policy support and current technological advancement which continues to decrease the cost of plugin vehicles, the 2020s will see electric cars grow to between 20% and 50% of car sales are already EVs. Volvo has recently announced that all its new cars launched from 2019 onwards will be partially or completely battery-powered, although it will continue to sell older models with internal combustion engines.

The Committee on Climate Change's recommendations for domestic actions to meet the UK's Paris Agreement commitment to undertake rapid reductions in emissions to 2050 suggests that 60% of new car and van sales in 2030 rising close to 100% of new sales in 2035 will be EVs, 40% of new small HGV sales are EVs, and 50% of new bus sales are low carbon (25% EV and 25% hydrogen)<sup>138</sup>. The Scottish Government has since stated that the sales of petrol and diesel vehicles will be banned in Scotland in 2032 and set a target that the proportion of the Scottish bus fleet which are low emission vehicles will increase to 50% by 2032<sup>139</sup>.

Nonetheless, as the average lifetime of a car is currently 10 to 15 years, there is likely to continue to be a significant number of petrol and diesel engine vehicles on the roads.

The Committee's central scenario for surface transport in 2050 is that 93% of cars and vans are EVs; 95% of buses are low carbon (half of them hydrogen and half EV); and 65% of Heavy Goods Vehicles (HGVs) are low carbon (40% use hydrogen and 25% EV)<sup>140</sup>.

There will be great challenges in the advancement of vehicle technology

Car manufacturers and industry experts expect that, with policy support and current technological advancement which continues to decrease the cost of plug-in vehicles, the 2020s will see electric cars grow to between 20% and 50% of car sales<sup>135</sup>.

There will be great challenges in the advancement of vehicle technology and fuel infrastructure to achieve penetration of the market by low carbon vehicles on this scale.

and fuel infrastructure to achieve penetration of the market by low carbon vehicles on this scale.

For example, the world's first double-decker hydrogen fuelled bus is being trialled on London's roads this year. However, the capital cost of a hydrogen bus is four or five times higher than for a diesel bus (which excludes the costs of new refuelling stations).

Following the Airdrie-Bathgate Rail Link and other recent electrification projects, the Edinburgh Glasgow Improvement Programme will electrify much of the rest of the network in Central Scotland<sup>141</sup>. The Scottish Government's aspiration is a rolling programme of electrification of 100km of single track per annum, eventually including all of Scotland's intercity routes. It has said that the percentage of rail track electrified will increase from 26% in 2017 to 35% in 2032142. The UK Government is also electrifying more of the GB rail network, including an 'electric spine' for rail freight.

<sup>135</sup> https://www.transport.gov.scot/our-approach/environment/carbon-reduction-on-roads/#43155

<sup>136</sup> www.ukh2mobility.co.uk/the-project/refuelling-infrastructure/

<sup>137</sup> Transport Scotland (2016), Switched on Scotland: A roadmap to widespread adoption of plug in vehicles

<sup>138</sup> Committee on Climate Change (2016), Scottish Emission Targets 2028-2032: The High Ambition Pathway Towards a Low-carbon Economy

<sup>139</sup> Scottish Government (2018), Scotland's Action on Climate Change

<sup>140</sup> Committee on Climate Change (2016), UK climate action following the Paris agreement

<sup>141</sup> Transport Scotland, http://www.transport.gov.scot/project/electrification-programme

<sup>142</sup> Scottish Government (2018), Scotland's Action on Climate Change

Rail freight operators have been unable to switch from diesel to electric traction due to a lack of electrification of the 'last mile' to and from freight terminals and considerations such as a lack of electrified diversionary routes and tight margins.

However, the very large cost increases in some ongoing electrification, and other rail infrastructure projects in Scotland<sup>143</sup> and the UK<sup>144</sup>, along with new restrictions on Network Rail's borrowing following its reclassification as a public body, is delaying the programme (in some cases in England and Wales by at least five years).

Network Rail has been developing the potential of new battery technologies, to work with overhead wires, to expand electrification more quickly and comprehensively<sup>145</sup>. Germany is planning to introduce the world's first fleet of hydrogen-powered trains<sup>146</sup>.

As transport becomes increasingly electrified, this will strengthen the link between transport and energy. While demand for electricity has fallen in recent years, driven by energy efficiency measures, the electrification of transport and heating would reverse this trend. One scenario modelled by National Grid is that electricity peak demand in the UK could be as high as 85 GW in 2050, compared to around 60 GW today<sup>147</sup>.

Higher penetration of variable renewable energy generation causes challenges in meeting demand when it spikes at certain times of day and challenges with oversupply and negative pricing during hours of low demand<sup>148</sup>. EVs are projected to increase demand at those times of high demand<sup>149</sup>. The data available at present suggests that owners are currently more likely to charge their EVs during morning and evening peaks than on weekdays<sup>150</sup>. National Grid modelling has found that without successful charging behaviour management, electricity demand could be 8GW higher in 2030. With smart charging, controlled by an active management system outwith the time of peak demand, the increase would be lower at 3.5GW - but this is still approximately the capacity of the new nuclear reactors at Hinkley Point<sup>151</sup>.

The increased adoption of EVs may provide potential storage capacity which can absorb intermittent loads from renewable generation, help integrate more

As transport becomes increasingly electrified, this will strengthen the link between transport and energy.

microgeneration and increase energy efficiency<sup>152</sup>. Trials are taking place, but some are concerned that such services may never be profitable due to battery degradation and connection costs<sup>153</sup>.

Companies, such as Panasonic, are beginning to look to provide both mobility and energy in one package<sup>154</sup>. The merging of SolarCity and Tesla<sup>155</sup> was the first coming together of a mobility provider and an energy provider<sup>156</sup>.

While switching from internal combustion engines to EVs will increase electricity bills, there will be savings at the petrol pump. For most people the cost of filling their car each year is about the same as their combined annual electricity and gas bill<sup>157</sup>. The annual fuel cost for pure EVs is about 10% of internal combustion engine cars<sup>158</sup>. There is the potential to provide more affordable mobility by integrating energy and transport policies. There will be a need to consider the potential benefits and disadvantages across society. For example, people in rural areas tend to pay more for their fuel and, on average, drive 53% further than people in urban areas<sup>159</sup>.

Access to reliable charging infrastructure remains fundamentally important.
A report for the RAC Foundation concluded that government across the UK has encouraged quantity rather than

- 143 Transport Scotland (2016), Commercial Assurance Review of the Rail Major Projects Portfolio
- 144 National Audit Office (2016), Modernising the Great Western railway
- 145 Transport Scotland (2016), Consultation on Scotland's Rail Infrastructure Strategy from 2019
- 146 https://www.dezeen.com/2016/11/04/germany-first-zero-emissions-hydrogen-powered-train-coradia-ilint-alstom-transport-news/
- 147 National Grid (2017), Future Energy Scenarios
- 148 GTM Research (2016), The Impact of Electric Vehicles on the Grid
- 149 GTM Research (2016), The Impact of Electric Vehicles on the Grid
- 150 http://myelectricavenue.info/trial-results
- 151 National Grid (2017), Future Energy Scenarios
- 152 Urban Foresight (2016), Energy Systems and Electric Vehicles
- 153 National Grid (2017), Future Energy Scenarios
- 154 http://news.panasonic.co.uk/pressreleases/panasonic-supports-first-smart-city-project-in-germany-1541603
- 155 https://electrek.co/2016/06/21/breaking-tesla-makes-an-offer-to-acquire-solarcity/
- 156 http://fortune.com/2016/10/17/tesla-panasonic-solar/
- 157 Marchant, Ian (2016), Elephants in Energy: 5 things to consider in energy policy, University of Strathclyde International Public Policy Institute
- 158 https://www.theguardian.com/environment/2017/dec/01/electric-cars-already-cheaper-to-own-and-run-than-petrol-or-diesel-study
- 159 UK Government (2012), The Cost of Fuel in Rural Areas

quality in the public charge point network, that there is a lack of standardisation in connectors and charging protocols which are confusing to the customer, and that there is a need for the appropriate charge points to be available on longdistance routes for both battery electric and plug-in hybrid vehicles. A third of car-owners in the UK have no off-street parking, as they live in a flat or a terraced house, and there is a need to provide charging infrastructure for them. Most concerningly, the report found that 13% of charge points were out-of-service at the same time in June 2017<sup>160</sup>. The operation of charging units requires digital connectivity, which can particularly affect the function of the charging unit in areas which lack mobile coverage or a reliable signal, such as many rural areas<sup>161</sup>.

In support of its announcement that the sales of petrol and diesel vehicles will be banned in Scotland in 2032, the Scottish Government plans further actions on EV infrastructure. It will support the increased deployment of public charging infrastructure to all parts of Scotland, create Scotland's first 'electric highway' as part of the A9 dualling, provide financial support for the installation of private charging infrastructure, improve the user experience of the network, by installing more than one charging point at locations where there is sufficient demand and improve reliability and fault management through such things as improved mobile phone network coverage<sup>162</sup>. This should also mean planning digital and charging infrastructure together.

As battery technologies advance, there is a risk that some of the public charging infrastructure provided for this generation of EVs may end up becoming under-utilised 'stranded assets'. There is a need to future-proof infrastructure development and the ability to share usage data can support this planning.

While energy, transport and digital have traditionally been separate policy areas, there will need to be an integrated strategy in the future<sup>163</sup>. This would potentially reduce the cost of the low carbon transition.

#### **Funding**

#### **Public Finances**

Following the increase in the UK's national deficit and debt since the financial crisis, there has been continuing reductions in public spending in an attempt to lower borrowing. The Brexit vote is forecast to weaken further the UK's fiscal position.

Scotland's resource and capital budgets are significantly lower in real terms than in 2010-11. The UK Autumn Budget did increase consequentials for resource spending in Scotland, but, in real terms, by 2019-20 the resource block grant is forecast to be around £500m lower than in 2017-18. In contrast, the block grant for capital expenditure is forecast to increase in real terms over the next two years<sup>164</sup>.

Higher inflation due to the lower exchange rate for the pound reduces the real-term value of spending, which makes cuts more likely over the medium term<sup>165</sup>.

The transfer of new fiscal powers means that the outlook for the Scottish budget also included devolved tax receipts and is

The UK has historically invested less in infrastructure than many other developed countries. As a share of GDP, investment in the UK has ranked in the lowest 10% of OECD countries for 12 of the last 21 years.

now crucially dependent upon Scotland's economic performance relative to that of the UK.

The UK has historically invested less in infrastructure than many other developed countries. As a share of GDP, investment in the UK has ranked in the lowest 10% of OECD countries for 12 of the last 21 years. In 2012, the World Economic Forum ranked the UK 24th for the overall quality of its infrastructure in its global competitiveness report, highlighting the legacy of underinvestment, including in transport networks.

Successive Scottish Governments have prioritised spending on transport infrastructure and services relatively to the UK. Spending was 11.5% below the UK average in 2002-03 but was, on average, 53% higher per person between 2006-07 and 2011-12 (which also partly reflects the devolution of the Network Rail grant to Scotland in 2006.) There has been high spending on roads and rail, and substantial public funding to support rail services in Scotland and ferry and air services serving the Highlands and Islands<sup>166</sup>.

<sup>160</sup> RAC Foundation (2017), Ultra-Low-Emission Vehicle Infrastructure – What Can Be Done

<sup>161</sup> Urban Foresight (2017), HITRANS Electric Vehicle Strategy

<sup>162</sup> Transport Scotland (2017), Switched on Scotland Phase 2: An Action Plan For Growth

<sup>163</sup> Marchant, Ian (2016), Elephants in Energy: 5 things to consider in energy policy, University of Strathclyde International Public Policy Institute
164 https://fraserofallander.org/2017/11/22/todays-uk-autumn-budget-the-implications-for-scottish-spending/

<sup>165</sup> Fraser of Allander Institute (2016), Scotland's Budget - 2016

<sup>166</sup> Institute for Fiscal Studies (2013), Government spending on public services in Scotland: current patterns and future issues

The Fraser of Allander Institute also found that the Scottish Government's high-profile spending commitments will require a serious re-prioritisation of spending in unprotected areas of the budget, such as transport. These could face cuts of between 10% to 14% by 2020-21<sup>167</sup>.

Transport Scotland spent £24m (38%) less on structural maintenance in 2014/15 than it considered necessary to keep trunk road condition at its current levels<sup>168</sup>.

Local government faces particularly serious challenges. Between 2010-11 and 2018-19, the local government Revenue Budget has fallen by 9.6%<sup>169</sup>. The Scottish Budget for 2018-19 did increase revenue funding by 0.2% in real terms and provide an uplift to the capital settlement<sup>170</sup>. However, non-statutory spending, such as local bus subsidies, has already been cut and faces even more comprehensive reductions. Overall council expenditure on roads maintenance decreased by 20% between 2010/11 and 2016/17<sup>171</sup>, and was 13% less in 2014/15 than was considered necessary to maintain the current condition of local roads<sup>172</sup>.

#### Tax Revenues From Transport

Funding for transport infrastructure and services has traditionally come from general taxation, including from motoring taxes, tickets for trains and buses, and user charging for HGVs (but not for cars or LGVs).

If, ultimately, all vehicles become electric, revenues from fuel taxes and VED in its current form would disappear altogether.

Tax also has a role to play in influencing behaviours to reduce economic, social or environmental costs.

Fuel duties and Vehicle Excise Duties are the main taxes on motoring and together raised around £38bn per annum in the UK in 2012-13. a sum almost twice the UK's entire transport budget<sup>173</sup>. However, changes in the transport market appear likely to lead to significantly lower tax revenues. Currently Vehicle Excise Duty (VED) is measured on the level of emissions from the car. With the development of low carbon vehicles. those who own cars in the future would pay significantly less VED. Policy Exchange has highlighted that while the Office of Budgetary Responsibility has estimated that receipts from fuel duty could increase from £28bn a year to around £40bn a year by 2030, projections based on the Committee on Climate Change's recommendations could reduce receipts to between £17bn-£30bn a year – potentially a shortfall of up to £170bn over the next 13 years<sup>174</sup>. If, ultimately, all vehicles become electric, revenues from fuel taxes and VED in its current form would disappear altogether<sup>175</sup>.

Should there be declining car ownership, tax revenues would fall regardless of whether EVs are adopted as soon as anticipated or not. Furthermore, MaaS and CAVs would encourage an even more widespread shift away from private ownership of vehicles to shared services which would be paid for through either a subscription or pay-as-you go model. In sectors such as tourism, disruptive, sharing economy business models have substantially reduced tax receipts and governments have been slow and unsure how to react.

The question of 'who pays?' will need to be addressed.

Many evidence-based reports have recommended that pay as you go should replace or reduce existing motoring taxes. This would vary according to time and location – higher during rush hours in congested areas, and lower at other times of the day and in rural areas – and would provide long-term stability in revenues to fund transport and the social and environmental effects of

MaaS and CAVs would encourage an even more widespread shift away from private ownership of vehicles to shared services which would be paid for through either a subscription or pay-as-you go model.

<sup>167</sup> Fraser of Allander Institute (2016), 'The Autumn Statement: Implications for Scotland'

<sup>168</sup> Audit Scotland (2016), Maintaining Scotland's roads: A follow-up report

<sup>169</sup> Audit Scotland (2018), Local government in Scotland: Challenges and performance 2018

<sup>170</sup> https://beta.gov.scot/publications/draft-budget-2018-2019-derek-mackays-response-to-patrick-harvie/

<sup>171</sup> www.improvementservice.org.uk/benchmarking/what-does-the-data-tell-us.html

<sup>172</sup> Audit Scotland (2016), Maintaining Scotland's roads: A follow-up report

<sup>173</sup> IPPR (2014), The Long Road to Ruin

<sup>174</sup> Policy Exchange (2017), Driving Down Emissions: How to clean up road transport

<sup>175</sup> The Institute of Fiscal Studies (2012), The road ahead for motoring taxes?

transport. However, at present, UK and Scottish governments have ruled this out – principally due to concerns about the acceptability to road users. Nevertheless evidence from London<sup>176</sup> and Stockholm<sup>177</sup> that it can be effective in reducing congestion, encouraging modal shift to public and active transport, raising funding and gaining public acceptability.

The wider market is already moving in the direction of a pay at the point of use model. Transportation network companies already utilise variable pricing based on supply and demand. The development of MaaS (and, in the longerterm, shared CAVs) would create a pay as you go, dynamic pricing system which enables users to understand their road use and make informed choices about their travel patterns. Smart technology is now making it quicker and less costly to introduce and operate pay as you go, especially in city regions. Pricing could take into account, for instance, the number of people in the vehicle, environmental impacts and maintenance of the infrastructure which is used<sup>178</sup>.

Government, with industry, needs to develop a long-term solution and explain this clearly to the public. MaaS should create significant benefits for the economy and society, individual users, and the market value of transportation network companies. It depends on the provision of high-quality infrastructure and services. In the new model, it may be possible to increase the level of private investment to fund improvements in infrastructure to deliver MaaS profitably,

In the new model, it may be possible to increase the level of private investment to fund improvements in infrastructure to deliver MaaS profitably, for example if there are partnership models.

for example if there are partnership models. Government needs to explore and promote innovative forms of financing, for example using Land Value Capture to help fund future connectivity. Tax may be focused on the point of use for consumers, being added to the subscription cost or directly charging the aggregator or operator. Consideration will also need to be given to how revenue streams for investment in rural areas and subsidies for socially-economically important services can be maintained.

# Infrastructure Maintenance and the Need for Ongoing Attention

Improving the condition of the existing infrastructure is essential for connectivity today and as the foundation for any successful future changes to mobility. For example, many unevenly surfaced local roads exhibit poor ride quality that renders them uncomfortable for road users, particularly for bus and cycle journeys. New modes will also rely on a good quality of running surface.

Both Scotland's road and rail networks have maintenance challenges and backlogs. Network Rail has had to increase significantly investment in renewals. Audit Scotland's report on roads maintenance concluded that the status quo is no longer an option if

there is to be any improvement in road condition<sup>179</sup>. Funding for maintenance needs to be prioritised.

There is some evidence at a UK level that the costs of maintenance of infrastructure are generally higher than in other parts of Europe<sup>180</sup>. If there are relatively high costs for the maintenance of transport infrastructure in Scotland, these need to be addressed and the options should be considered and acted upon. Audit Scotland has called for a plan and timetable for the sharing of local roads maintenance on a regional basis which has made very slow progress to date.

Smart, data driven asset management approaches to both road<sup>181</sup> and rail<sup>182</sup> maintenance using remote condition monitoring, risk-based maintenance and information from vehicles, have the potential to increase availability of the road and rail networks through reduction of unplanned maintenance time. Given the increasing interdependencies of transport, digital and energy infrastructure, maintenance of the latter two infrastructure services is also a priority for transport.

#### **Investment and Infrastructure Costs**

World-class transport connectivity is of fundamental importance to the success

<sup>176</sup> Transport for London (2015), Annual Report 2014-15

<sup>177</sup> The Institution of Engineering and Technology (2010), 'Road User Charging'

<sup>178</sup> Deloitte (2016), The future of mobility: What's next?

<sup>179</sup> Audit Scotland (2016), Maintaining Scotland's roads: A follow-up report

<sup>180</sup> Infrastructure UK (2010), Infrastructure Cost Review: Main Report

<sup>181</sup> Transport Scotland (2017), Future intelligent transport systems strategy

<sup>182</sup> Network Rail (2018), Route Business Scotland Route Strategic Plan

of modern economies. Substantial investment in transport infrastructure and services will need to continue to be a high priority. Scotland is trying to play catch-up on investment as demand increases, but there is a perception that networks in other countries are improving at a faster pace.

One of the ways of maintaining investment in this fiscal climate would be to address the relatively high costs of infrastructure in Scotland and the UK compared to other parts of Europe. These were substantiated by Infrastructure UK in a 2010 report as ranging from a factor of 10% to over 100% difference. It found that the higher costs were mainly generated in the early project formulation and pre-construction phases due to uncertainty about the programme of infrastructure, overly complex procurement approaches and fragmentation of the construction industry which has been a barrier to strategic investment in skills, technology and innovation. Infrastructure UK stated that here was a "clear opportunity to realise savings of at least 15% which can deliver sustainable benefits of £2-£3bn per annum<sup>183</sup>.

Transport Scotland is proposing to move to a 'pipeline' approach in which a decision to commit to a specific enhancement project is only taken when the business case is clear, the availability of suitable capabilities and resources in supply chains is confirmed, the appropriate choice for the individual of development, design and contracting model has been identified, and both price and affordability are certain<sup>184</sup>.

Smart mobility requires a combination of transport, digital and energy infrastructure and technologies and the current transport assessment methods may not capture the full economic benefits from integrated solutions across these different systems and networks.

The Commission has not seen evidence that Scotland and the UK are making progress towards this outcome. Initial work carried out by the Transport Research Institute at Edinburgh Napier University into the comparative headline costs for similar transport infrastructure projects highlights strikingly higher costs in Scotland than in Germany<sup>185</sup>. With budgets under pressure and revenues under threat, there is a pressing need to understand and address any differences in costs.

Deciding on the priorities for investment will be challenging given the uncertainties and the potential, in the longer-term, for smart infrastructure, MaaS and CAVs to reduce the need for some projects by making more effective use of capacity. Smart mobility requires a combination of transport, digital and energy infrastructure and technologies and the current transport assessment methods may not capture the full economic benefits from integrated solutions across these different systems and networks.

Traditional methods such as Benefit-to-Cost-Ratio (largely based on journey times saving multiplied by potential users) will need to be augmented by new approaches based on Multi-Criteria Decision Analysis. These may include, for example, contribution to Scotland's

National Outcomes, reliability and resilience, and scenario planning.

In England and Wales, significant third-party funding will become one of the main factors which will help to prioritise rail projects for delivery in the next spending period. The Scottish Government is not proposing such a strict requirement but is exploring the potential for additional sources of innovative funding methods that could be used to support delivery<sup>186</sup>. Network Rail is appointing a Head of Route Business Development in Scotland whose role will include liaising with city deal teams and local authorities to investigate opportunities for third party funding<sup>187</sup>.

The National Needs Assessment for UK Infrastructure<sup>188</sup>, to which SCDI contributed, described a number of issues and cross-cutting priorities related to the infrastructure challenge, including:

- Delivering modern infrastructure for Britain will need a strategic combination of investment to provide new capacity alongside policies and technologies to ensure that capacity is used in the most efficient way.
- Technological innovation means that people are paying for infrastructure services in different ways – from Uber car rides to bundled telecoms packages.

<sup>183</sup> Infrastructure UK (2010), Infrastructure Cost Review: Main Report

<sup>184</sup> Transport Scotland (2016), Consultation on Scotland's Rail Infrastructure Strategy from 2019

<sup>185</sup> Rye. T, http://www.scotsman.com/news/transport/scots-pay-high-price-for-better-road-and-rail-links-1-4158461

<sup>186</sup> Transport Scotland (2016), Consultation on Scotland's Rail Infrastructure Strategy from 2019

<sup>187</sup> Network Rail (2018), Route Business Scotland Route Strategic Plan

<sup>188</sup> Institution of Civil Engineers (2016), National Needs Assessment: A Vision for UK Infrastructure

 We must reduce the cost of building and operating infrastructure. Innovation and training will be key – for example, use of off-site manufacturing and Building Information Modelling in construction, and sensor technology to help cut the cost of maintenance.

## **Industrial Strategy**

These intelligent transport systems opportunities can only be developed with major, long-term investment in digital, transport and energy infrastructure and services. Ways will need to be found by government, in consultation with industry, to maintain investment in new and existing infrastructure and services to increase competitiveness and inclusive growth.

Partnerships are likely to be a core part of the solution, between government and industry and business-to-business. There are examples from around the world in both digital and transport in which the private sector, attracted by government and the market, is investing in infrastructure alongside or instead of government<sup>189</sup>. This may be to enable them to provide better services which generate increased revenues or to innovate with new products or services which can then be sold globally. There is evidently a very strong market push towards MaaS, EVs and CAVs. By 2035 the global market for connected and autonomous vehicle technologies is predicted to be worth £63 billion<sup>190</sup>.

Governments in other European countries are actively developing MaaS, with Finland leading the way and the EU having a more general focus in developing MaaS across member states.

MaaS Global, which is funded by several private investors to improve the connectivity of Finland and develop MaaS, aims to be the single aggregator in the Finnish transport system through its creation of the 'Whim' app. This provides commuters with real-time data and information from all mobility providers within Helsinki, allowing them to personalise their journeys and also pay for all methods through one app. The app helps by providing assistance to delivering a door to door service whilst also tracking carbon footprint and offering rewards via mobility points for those who reduce their carbon footprint in journeys. It is interesting to note that Toyota and Transdev have invested significantly in MaaS Global.

There are examples from around the world in both digital and transport in which the private sector, attracted by government and the market, is investing in infrastructure alongside or instead of government<sup>187</sup>.

The UK Industrial Strategy White Paper<sup>191</sup> proposes a more active role for government, working with business, universities and government laboratories to develop and adopt innovation. The Industrial Strategy Challenge Fund will back technologies at all stages where the UK has the potential to take an industrial lead, from early research to commercialisation. The 'Future of Mobility' is one of four Grand Challenges in the Industrial Strategy.

The UK Government set up the Centre for Connected and Autonomous Vehicles (CCAV) in 2015 which has a research programme worth up to £200m plus a further £100m to be

matched by industry to establish a testing ecosystem. Following earlier funding which supported driverless car trials in Greenwich, Bristol, Milton Keynes and Coventry, it has announced<sup>192</sup> investment in a cluster of excellence in CAV testing in the UK's 'automotive heartland' along the M40 corridor between Birmingham and London, including:

- Public test facilities in a complex, realworld urban or city environment
- A controlled test environment representative of driving in a city
- A realistic and controlled high-speed, test environment.

The UK Government also recently announced funding for a wide-range of driverless and low carbon vehicle projects <sup>193</sup>, including projects using cars and pods platooning, or going in formation, to transport passengers from Stockport train station to Manchester Airport. The UK Government has commissioned a review of the case for a new research institution to act as a focal point for work on battery technology, energy storage and grid technology. A competition has been launched for projects to help build

<sup>189</sup> The Economist (October 1st 2016), Its starts with a single app

<sup>190</sup> https://www.gov.uk/government/news/government-sets-out-next-steps-in-establishing-the-uk-as-global-leader-in-connected-and-autonomous-vehicles

<sup>191</sup> HM Government (2017), Building our Industrial Strategy

<sup>192</sup> https://www.gov.uk/government/news/government-sets-out-next-steps-in-establishing-the-uk-as-global-leader-in-connected-and-autonomous-vehicles

<sup>193</sup> https://www.gov.uk/government/news/over-109-million-of-funding-for-driverless-and-low-carbon-projects

infrastructure for hydrogen vehicles, including fuel stations<sup>194</sup>.

Scottish-based participation in these UK projects has, so far, been limited. However, Edinburgh-based Machines with Vision has recently secured a large project in collaboration with Jaguar Land Rover and Durham University to develop and test 'a reliable vehicle localisation framework' 195.

Scotland's roadmap for EVs was refreshed in 2017 and includes an Innovation Fund for low carbon energy infrastructure solutions, such as better linking electric vehicles with renewable energy and energy storage and systems and the acceleration of public procurement<sup>196</sup>. In addition to the Aberdeen hydrogen demonstration project, Fife will soon have a hydrogen refuelling station and a fleet of vehicles, including the world's first hydrogen fuelled refuse trucks, and Orkney will use hydrogen to power vessels in Kirkwall harbour<sup>197</sup>.

However, there is some uncertainty about funding. The demonstration project in Aberdeen has been funded by the EU and there are no commitments yet from the UK and Scottish governments to replacing this source should this be required post-Brexit.

In its Smart Cities Scotland Blueprint<sup>198</sup>, the Scottish Cities Alliance, the collaboration of Scotland's seven cities and the Scottish Government, recommends that Scotland should

attract investment and create opportunities to test, develop and commercialise smart mobility solutions in Scotland's cities.

City Region Deals include substantial capital funds from government which can be matched with revenue funds from public bodies, educational institutions and industry. These could provide a good basis for developing new test sites for linked solutions for mobility, data and energy, for example in strategic housing and commercial developments.

MaaS Scotland, a network of companies, public sector agencies and research centres working together to develop and deliver MaaS in Scotland, was launched at the European ITS Congress in Strasbourg in 2017 and is developing a programme of phase 1 MaaS projects across Scotland. MaaS Scotland is supported by Scottish Enterprise and hosted by Technology Scotland and ScotlandIS. It has 65 private and public members and has already gained a high profile internationally placing Scotland at the forefront of MaaS development.

Transport is an important sector of the Scottish economy which, at present, employs 98,000 people<sup>199</sup>. Changes in mobility present a challenge to the transport sector and to the wider economy. Social disquiet about widening inequality and the potential for automation of jobs to polarise wealth still further will continue to make inclusive growth a high priority for national and local government. On the other hand,

The market will continue to drive these changes and there is potentially a great industrial opportunity. There is a growing differentiation between world-leading digital nations and the rest and, to remain economically competitive, Scotland will need to accelerate its pace.

there will be demand for people with skills in data science and data applications. Training people in these skills will be a key to making changes in mobility work for Scotland economically and socially.

The market will continue to drive these changes and there is potentially a great industrial opportunity. There is a growing differentiation between world-leading digital nations and the rest and, to remain economically competitive, Scotland will need to accelerate its pace. If Scotland wants to be at the leading edge of these innovations in mobility, government and industry need to act now to develop and promote opportunities which are attractive to global investment.

#### **The New Transport Model?**

This section of the report has attempted to identify the drivers of change in the transport market, globally and in

<sup>194</sup> https://www.gov.uk/government/news/23-million-boost-for-hydrogen-powered-vehicles-and-infrastructure

<sup>195</sup> https://www.gov.uk/government/news/transformational-investment-in-off-road-self-driving-technology

<sup>196</sup> Transport Scotland (2017), Switched on Scotland Phase Two: An Action Plan for Growth

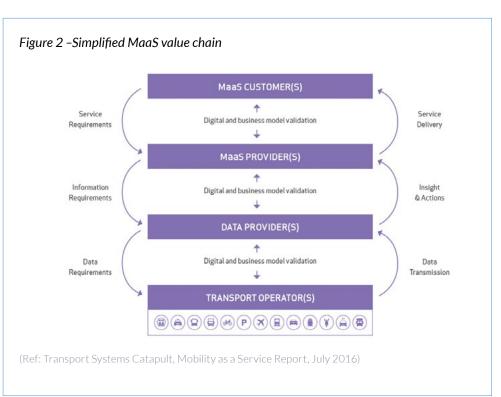
<sup>197</sup> https://www.transport.gov.scot/our-approach/environment/carbon-reduction-on-roads/#43155

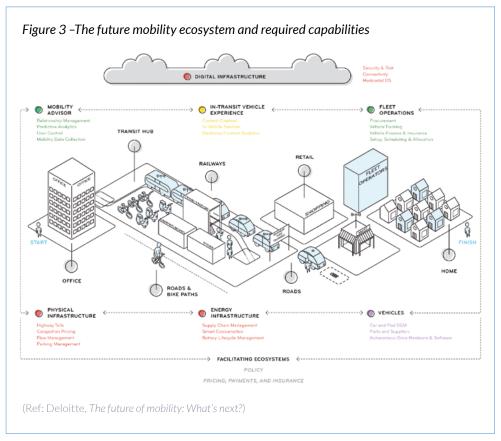
<sup>198</sup> Scottish Cities Alliance (2016), Smart Cities Scotland Blueprint

<sup>199</sup> The Scotland Institute (2016), Developing a Post-Brexit Industrial Strategy for Scotland

Scotland. There are many uncertainties, but it does seem to be the case that the mobility services value chain will be transformed at an accelerating rate, with the digitally-enabled integration of different modes of transport, public and private transport, and – potentially – passenger and freight transport, into MaaS. There are many illustrations of the potential new transport value system and ecosystem. The following graphics from the Transport Catapult and Deloitte reports are useful examples:

Assuming that changes of this kind will transpire; the next section of this report will focus on the areas which the Commission proposes that the Scottish Government and industry should most urgently consider.









# Part 3 - Where to Focus

## **Scottish Government Strategy**

The work of the Commission has highlighted that innovation in the market is integrating all sectors (physical and digital) of connectivity.

Infrastructure systems and networks will become increasingly integrated and interdependent. This will potentially increase their resilience, but it does mean that a failure in one system or network could affect a range of others. Resilience will become a characteristic which is vital across all infrastructure.

Large-scale electrification of heat and transport services, which is critical to meet climate change targets, is anticipated. Digitalisation will take place in both the energy and transport sectors to develop smart infrastructure, monitor and maintain it operationally, personalise services for customers, and manage demand and dynamically price – all utilising data.

In response, government in Scotland needs to develop an integrated strategy across energy, digital and transport infrastructure and policies.

In 2017 the Scottish Government published Scotland's refreshed Digital Strategy<sup>200</sup> and the Scottish Energy Strategy<sup>201</sup>.

#### Digital

With specific reference to transport, the Digital Strategy commits the Scottish Government to:

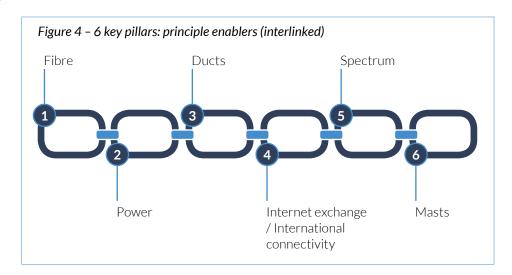
- Develop intelligent transport systems which will increase capacity and support the further development of smart integrated ticketing across buses, trains, trams and ferries throughout the country
- Ensure that 4G coverage is available throughout most of Scotland and on all key transport routes – A and B roads and main railway routes.

The Scottish Government and Scottish Futures Trust have been working to define and deliver the key enablers required to deploy the digital infrastructure needed to make Scotland a competitive nation in the next 15 years and beyond.

Six key pillars have been identified as essential to create the environment for Scotland to be ready for new 5G connectivity which will underpin and enable future transport system needs<sup>202</sup>:

The International Telecommunications Union has defined that 5G-ready networks will be capable of 20Gbps. One key challenge is that existing copper infrastructure will be unable to sustain such a future high-speed resilient network. **Fibre** is critical, and the fundamental requirement will be to have fibre reach as far into the network as possible whether this is to small cell locations on street furniture, to rural mast locations, or to buildings and premises.

The ability to access and more efficiently install underground **ducting** infrastructure is critical to enabling this



proliferation of fibre and will require collaborative working between industry and the public sector to ensure the correct infrastructure is delivered in the right place at the right time especially when planning new developments and buildings or new infrastructure.

In terms of **masts**, there will be a need for a significantly higher concentration of antenna technology, particularly in urban areas. This will need the cooperation of government and local authorities to provide more readily available access to street furniture and other infrastructure to enable deployment. All of this will need to be underpinned by a densely-structured fibre network and the latest in ultrafast millimeter (mm) wave technology.

Due to the higher data demand transferring between a significantly greater number of devices and antenna, a more effective and efficient use of **spectrum** will need to be identified; and there will need to be more spectrum capacity made available to cope with that demand. With an increase in new equipment being installed, all energy hungry, greater consideration and innovation will be required regarding sustainable energy supplies both in urban and rural area and battery **power** technology.

The Internet of Things is fast becoming a reality. Combined with the greater number of transactions and services being undertaken, this will require near instant access to information resources, and for that information to be closer to the user. Relying on information being stored in **internet exchanges** in

London or Manchester will not deliver the 5G user experience, and the latency requirement of <1 millisecond will mean peering with Internet Exchanges located in Scotland is also a fundamental requirement. Likewise, delivering international connectivity for Scotland will be key to delivering resilience, speed and opportunity.

#### Energy

The Scottish Energy Strategy proposes to take an integrated, 'whole-system' approach to energy across electricity, heat and transport. It draws on work by Transport Scotland and Urban Foresight which concluded that "large numbers of EVs across Scotland will offer an invaluable resource to support 'whole-system' energy solutions, providing significant and distributed energy storage capacity, able to absorb intermittent loads from renewable generation, help integrate more microgeneration, increase energy efficiency and potentially be a source of grid power input when required"203. There may be opportunities for community energy groups to provide charging infrastructure in rural areas.

The 'My Electric Avenue' project tested the impact of demand from EVs on local electricity networks in 2030. It found that across Britain 32% of low voltage (LV) feeders (312,000 circuits) will require intervention when 40% – 70% of customers have EVs, based on 3.5 kW (16 amp) charging. The costs to reinforce local networks has been estimated to be at least £2.2bn by 2050. However, widespread adoption of smart chargers would reduce the cabling and, therefore, spending required. New EVs

can charge at a rate (7kW), double that of those used in the modelling.

Centralised charging sites and/or inductive charging, which does not use cables or wires, could reduce the need for overnight charging. This would be especially useful for buses which need to be kept in service during the day. A trial project in Milton Keynes currently uses inductive chargers at bus stops to top up the batteries of buses while they are in service<sup>204</sup>. These would change the infrastructure investment which would be required.

The project concluded that with charging rates and battery capacities continuing to increase further, more work is needed to understand what this means for local electricity networks <sup>205</sup>.

#### Transport

The Scottish Government has also launched a review of the National Transport Strategy. This will: "set out an updated vision for what kind of transport system we want for the whole of Scotland over the next 20 years or so and how we plan to get there. It will look at how we can successfully address the strategic challenges facing our transport system and how we can take advantage of any opportunities that present themselves. It will also inform the Strategic Transport Project Review by providing a clearly defined set of strategic transport objectives." The strategy will be aligned with "the emerging policy and legislative landscape in Scotland including the outcomes from the independent planning review, Climate Change Plan, local government review, Enterprise and Skills review, City and Region Growth Deals and the Transport Bill"<sup>206</sup>.

<sup>203</sup> Transport Scotland and Urban Foresight (2016), EVs & Energy Systems

<sup>204</sup> National Grid (2017), Future Energy Scenarios

<sup>205</sup> http://myelectricavenue.info/

#### Plan of Recommended Actions

This report has been careful to identify the uncertainties about the future of transport. However, we know that major changes are coming. There cannot be inertia in planning for the future. Improving connectivity is an essential component of any strategy to increase Scotland's international competitiveness.

The Commission has identified characteristics which it believes will future-proof Scotland's connectivity under a range of different scenarios. Thinking through the potential changes that these characteristics will bring should inform better decision-making about the policy approach to change in transport and connectivity.

The Commission has been particularly concerned with policy in Scotland and therefore many of the recommended actions are principally directed towards the Scottish Government and/or industry in Scotland. However, the Commission recognises that key policy responsibilities and major decisions will be taken by government, regulators and

industry at UK, European and global levels – and that even in their areas of responsibility government in Scotland will have to be in close contact with policy and industry developments at those levels to ensure an integrated approach.

The Commission recommends actions grouped into three themes:

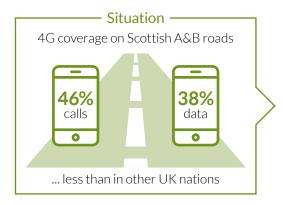
- 1. Future-proofing
- 2. Funding
- 3. Decision-making

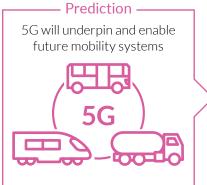
The Commission has taken a long-term perspective and linked to these themes it is suggesting timescales for key actions – 0-5 years, 5-10 years and 10-20 years. It is fully aware of the uncertainties about mobility and connectivity in 10 to 20 years and inevitably there is less detail in this period. A number of actions for earlier periods will be high priorities – for example, cyber-security. It is also important to state that the Commission does not mean that the issues for 10-20 years can be ignored. There is a need to start horizon-scanning, discussing and planning for them now.

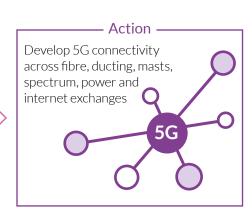
# Future-proofing



# Develop a Unified 5G Environment







Recommendations	Define a delivery plan to deliver the substantial further investment in digital connectivity and services which will be needed to accommodate future mobility systems, including a world-class user-focused experience, consistent with the emerging international standards.
0-5 years	Formulate a Delivery Plan through joint work by government, regulators, business and the telecoms sector to develop a unified 5G digital environment underpinned by full fibre and mobile connectivity.
	Remove 'not-spots' for voice and data coverage on the strategic transport network and key regional and local infrastructure, for example, through incentivising further commercial investment, the Universal Service Obligation and other public interventions.
	Adopt a flexible, technology-neutral approach to the roll-out of smart ticketing options, focusing on outcomes and adaptability to enable the latest demand for technologies.
	Work with the bus industry, emerging digital mobility providers and Transport Scotland to accelerate the expansion to rural areas of non-cash and multi-operator bus transactions now available in urban areas with other emerging digital mobility providers, to expand these across public transport services.
	Challenge and support all parts of the transport industry to embrace the use of data – for example, to balance supply and demand in a much more flexible and efficient way.
	Accelerate planning for the cyber-security of personal and business data in MaaS, CAVs, and infrastructure networks – protections must be robust and up to a high standard and guarantee that appropriate safety measures and plans are in place if systems are hacked.
	Start the rollout of the Digital Railway programme in Scotland.
5-10 years	Eradicate any remaining 'not-spots' for voice and data coverage across the regional and local surface transport network.
	Provide the digital capabilities for the safe and efficient use of CAVs, i.e. the transport control systems which ensure that they are fully aware of their current surroundings and can 'talk' to all other CAVs and smart infrastructure.
	Significant progress in the rollout of the Digital Railway programme in Scotland.
10-20 years	Provide the digital capabilities for fully autonomous (stage 5) vehicles.
	Deploy the full Digital Railway programme in Scotland (within 25 years).



## Develop Scotland as a World-Leader for Reliable Transport



# Prediction —

As climate changes,

10-20%

of Scottish roads and railways have significant likelihood of flooding



management approaches

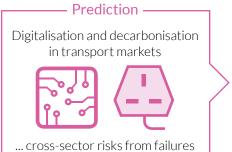
Recommendations	Fully recognise the value of the reliability and resilience of connectivity for the modern economy, and take action to improve maintenance and plan for challenges, such as climate change.
0-5 years	Protect and, if possible, increase local and national funding for road and rail maintenance. The innovative measures will still rely on sound, basic infrastructure.
	Continue to improve responses in times of unplanned disruption.
	Make reliability and resilience explicit in the strategic outcomes for transport in the refreshed NTS, with the aim that Scotland becomes a world-leader.
5-10 years	Plan and deliver long-term investment in maintenance and smart asset management for monitoring and maintenance.
10-20 years	Develop a comprehensive network of tested diversionary options for important road and rail routes, especially those which are vulnerable, with the necessary capabilities for both passenger and freight transport, including digital and low carbon infrastructure.



# 'Whole-system approach'

# Develop a Fully Integrated Approach across All Infrastructure that Enable Connectivity





A cohesive 'Connectivity' strategy

Recommendations	Integrate infrastructure systems
0-5 years	Ensure that oversight, delivery, monitoring of all strategies is joined-up. Ensure that "National Transport Strategy 2" is well-informed on the latest mobility systems developments.
5-10 years	At the time of their next reviews, integrate transport, digital and energy into a single, cohesive 'Connectivity' strategy.
	Build greater resilience into all infrastructure systems, understanding that their interdependencies can increase resilience, but could also mean that a failure in one system could cause failures across a range of others.
10-20 years	Build upon years 0-10.



## Develop Infrastructure and Market for Low Carbon Transport

journey times in cities.

urban areas.

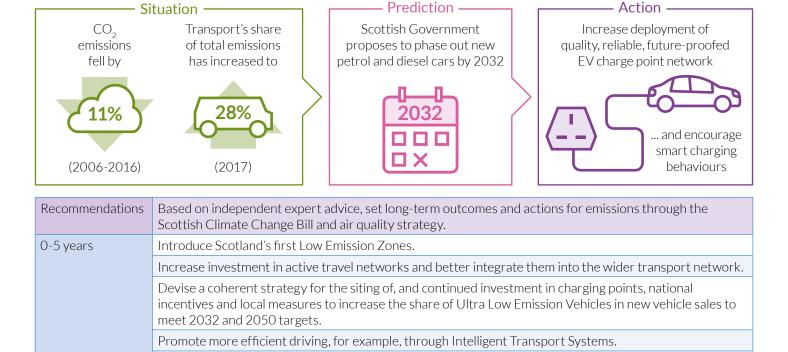
generation wires.

electrification.

charging.

5-10 years

10-20 years



Set targets for congestion and develop policies accordingly, e.g. a target to maintain or reduce average bus

Through the refresh of the STPR, decide what investment in high-capacity mass transit and demand management systems will be needed to deliver the benefits of MaaS and CAVs and prevent gridlock in

Upgrade local electricity networks to enable them to accommodate increasing demand from EVs for

Improve freight operations through the creation of Urban Consolidation Centres and modal shift to rail.

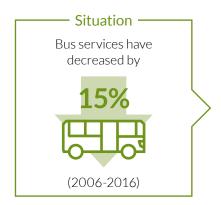
Continue the rolling programme of electrification of Scotland's railways, and maintenance of first

Determine the optimum mix of overhead wires and new battery technologies for further railway

Extend electrification of the rail network to Aberdeen and Inverness.



Develop Inclusive Mobility Policies in National Transport Strategy







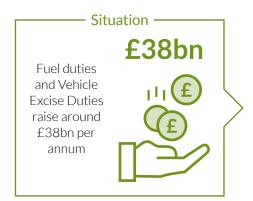
Recommendations	Government, regulators and the transport, technical and energy industries should work together to understand industry trends and strengthen the approach to inclusive growth in mobility in the NTS2 review, supporting widespread prosperity and a stronger market.
0-5 years	Work with industry to maintain socio-economically important public transport services which will face further declines in revenues. Explore the use of emerging mobility services that will deliver public transport in new and innovative ways.
	Develop the digital skills which will be needed for intelligent mobility systems.
5-10 years	Work with industry to realise the potential mobility benefits of MaaS and CAVs for those currently restricted in their transport options and to address risks – such as affordability of services and dynamic pricing for people in lower income brackets and a lack of availability for people in rural areas.
	Work with industry in the transition to EVs to ensure affordable mobility when paying through electricity bills rather than at the pump, for example, in rural areas where fuel prices are higher and people travel more.
10-20 years	Retrain workers who will lose their jobs as transport systems are increasingly automated for other roles.
	Develop large and small scale 'community resilience' opportunities from changing land use – such as a reduced need for on-street parking – for regeneration, urban green spaces and active travel.

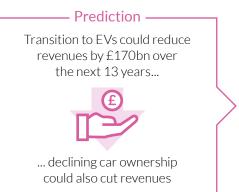
# **Funding**



# **Maintaining Investment and Services**

**Develop Long-term Transport Funding Strategy** 





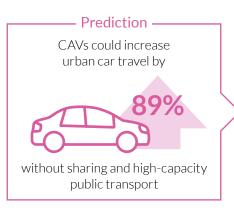


Recommendations	Develop long-term strategy for funding infrastructure and services as the way that people pay for infrastructure services changes and the growth of MaaS, EVs and CAVs reduces revenues from motoring taxes and from public transport fares.
0-5 years	Commission an independent review of transport funding and discuss with the public and private sectors their interests in funding the maintenance and development of high-quality and inclusive networks, both physical and digital, which underpin personal mobility and business profitability.
	Explore the potential of innovative forms of funding like Land Value Capture and the pay at the point of use.
	Protect funding for socio-economically and environmentally important services.
	Specify services which are required rather than prescribing methods to deliver them in interactions with potential service suppliers.
	Support regional and local measures to help fund infrastructure and services and/or influence behaviours to reduce economic, social and environmental costs.
	Significantly reduce the costs of building and operating infrastructure, using international comparators without impacting on safety or quality, as expert reviews recommend, e.g. procurement, planning reform, innovation in construction and sensor technology to help cut the cost of maintenance.
5-10 years	As the market and technologies continue to move towards pay-at-the-point-of-use with dynamic pricing based on supply and demand, develop market-based revenue streams which support economic, social and environmental outcomes, efficient utilisation of capacity and informed choices about travel, e.g. generation of new revenue streams from advertising and added value services, or tax at the point of use, tax on the cost of subscriptions and/or tax on transport aggregators or operators.
10-20 years	Build upon years 0-10.



# Develop Future Mobility Systems in City Region Deals







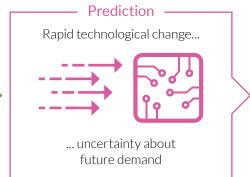
Recommendations	Further develop ways of planning, funding and delivering meaningful regional infrastructure improvements.
0-5 years	Future-proof city deals and city investment plans for future connectivity systems.
	Explore the potential for funding from a regional infrastructure levy and/or other innovative funding mechanisms to support the development of future connectivity systems.
5-10 years	Consider methods to capture a share of the increased land and development value generated by the improved connectivity to fund the transportation facility, e.g. based on Land Value Capture or property development taxation of developments or a mix of both.
10-20 years	Continue to support the development of future connectivity systems through city deals and city investment plans.
	Use funding from a regional infrastructure levy and/or other innovative mechanisms to support the development of future connectivity systems.

# **Decision-making**



Develop Broader Assessment Methods for Investment







Recommendations	Reform both operational and strategic decision-making – based on the opportunities from digitalisation and data and the uncertainties which disruption in the transport market and new technologies will create – with a focus on outcomes, such as increasing competitiveness and inclusive and sustainable growth.
0-5 years	Continue to deliver projects featured in the long-term Infrastructure Investment Plan.
	Incorporate scenario-planning and data on potential changes in the economy, energy and the environmental conditions <sup>207</sup> into strategic decision-making.
	Use Multi-Criteria Decision Analysis to assess projects, e.g. based on contributions to National Outcomes, revenue generation for Scotland's tax base and the potential for alternative solutions to hard infrastructure – as well as Benefit-to-Cost-Ratio calculations.
	Future-proof infrastructure so that it has compatibility and functionality for future transport systems, recognising that the extra costs will still be much lower than the costs of retro-fitting infrastructure.
	Work with Regional Transport Partnerships and local authorities to increase knowledge of the issues with the deployment of future mobility systems and to ensure appropriate cross-boundary compatibility.
	Public sector modelling should blend its data sets with the generally more mobile modelling of the private sector, which includes predictive analysis and more closely involve operators.
	Consider if Network Rail's long-term planning process for investment – which links maintenance and renewal of assets with investment to meet future demand, priorities and aspirations – should be extended to roads.
	Through the planning review and NTS review, ensure that, integrated with national strategy, there are joined-up, outcome-focused and flexible strategies planned and delivered at a city region level, which directly address issues such as prioritisation and funding, e.g. by Regional Transport Partnerships.
5-10 years	Commit to critical decisions when needed (understanding that there are also potentially large risks and costs in making no decisions) but be adaptable enough to accommodate changing circumstances and new technologies and business models <sup>208</sup> .
	Prioritise and integrate connectivity between Scotland's city regions and:  - Scotland's international airports and port gateways, including those in the rest of the UK  - The Northern Powerhouse and London, including HS2  - Rural and remote areas of Scotland.
10-20 years	Review and re-shape transport networks to best deliver future demand and services, economic, social and environmental outcomes, resilience, and affordability.



# Develop Updated Framework for Integrated Mobility



10-20 years

# Prediction Data increases opportunities for flexible, demand-responsive services

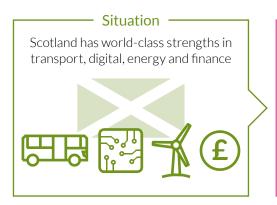
Embrace data
analaytics, innovation
and partnerships,
accelerate national
coverage of
multi-modal,
multi-operator,
non-cash
ticketing options

Recommendations	Review current legislation and regulation so that they are fit-for-purpose for changes in the transport and mobility market and positively shape economic, social and environmental outcomes.
0-5 years	Bring together a partnership group of industry, government and regulators to take forward the issues which are identified in the report and present proposals to the Scottish Government to inform its strategic thinking.
	Learn from the approaches being taken in other countries to revising transport legislation – as MaaS is developed and the differences between different modes (private/public transport, passenger/freight transport) are reduced – to bring it into harmony, e.g. Finland, US states, etc.
	Launch a national conversation about data to develop clear and appropriate regulation of openness, ownership and security, consistent with codes of best practice developing internationally.
	Plan to support operators seeking greater flexibility to better meet the needs of customers in response to data, for example by changing services or providing them in different ways or in partnership, review and amend competition law, rail franchise contracts and bus subsidies, e.g. a scheduled rural bus route with a low level of patronage might be more effectively and efficiently served by an on-demand bus or ride-sharing.
	Given the pivotal role of the MaaS aggregator and winner-takes-all dynamic of scale, network effects and control of data, and the high barriers to entry at a city region level, review the benefits and disadvantages of:  - Promoting innovation and competition  - A single MaaS aggregator – as it may be less difficult to regulate the generation, use and security of data  - Government providing this role or creating a public-private partnership, social enterprise or alternative partnership model – taking into account the risks of stifling innovation and being misaligned with international models, making Scotland less attractive for MaaS investment.
	Give comprehensive consideration to the many legislative and regulatory challenges with the emergence of CAVs, including drones.
5-10 years	Build on lessons learned in years 0-5.

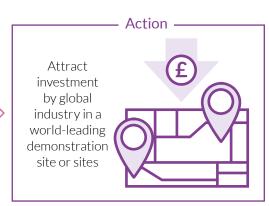
Build on lessons learned in years 0-10.



Develop Scotland as a Location for Innovations in Mobility







Recommendations	Ensure that Scotland is suitably placed to take the opportunities presented by innovations in future connectivity systems, building on experience from elsewhere.
0-5 years	Bring together Scotland's transport, technical, energy and finance sectors, with national, regional and local government, the Scottish Cities Alliance and regulators, to explore the opportunities and risks for Scotland.
	Consider the potential for an attractive business case to test, develop and commercialise a world-leading project for investment from global industry, e.g. a demonstration site or sites of scale in a new town in development, whether a distinct community or as a new area of a city region.
	Consider the potential to introduce a MaaS Investment Fund in Scotland, based on funds such as the Transport Innovation Fund and the Urban Challenge Fund.
5-10 years	Based on the success of, and market for, Scottish projects, commercialise, develop skills and export globally.
10-20 years	Build upon years 5-10.

