HORIZON SCAN

THE IMPLICATIONS FOR URBAN TRANSPORT POLICY OF TRANSFORMATIVE SOCIAL AND TECHNOLOGICAL CHANGE

INTRODUCTION

Our major urban areas are experiencing a period of accelerating technological and social change. Demographics, the capabilities of smart devices, the expectations of citizens, and even the climate itself are all changing. The pace of change can be bewildering, as in a few short years new developments, from social media to Uber, move rapidly from the margins to the mainstream. What not so long ago was seen as science fiction (from autonomous vehicles to tablets that talk) becomes science fact. Either in the here and now or just over the horizon.

The challenge for our cities is how they respond – will they be swamped, constantly playing catch up to successive waves of change? Or will they be forward thinking and respond dynamically, intelligently and adeptly? In this report we provide a concise summary and horizon scan of likely transformative trends, the implications for urban transport policy, and how forward thinking cities and city regions might respond.

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CITIZENS AND LIFESTYLE

CHANGES IN DEMOGRAPHICS AND LIFESTYLES AND THE RISE OF THE SHARING ECONOMY ALTER MOBILITY CHOICES.

Shifting Patterns and Expectations for Living and Working

In addition to an ageing society, changing household sizes and shifting working and living arrangements will fundamentally influence expectations towards transport services.

The global trend towards smaller and less conventional household units is continuing to gather pace. In OECD countries, the average household size dropped from 2.8 to 2.6 people from 1985 to 2005. By 2011, more than half of all households were without children. In the UK, one-person households are expected to increase by 35% from 2006 to 2031, which is largely due to an ageing population, but also lower marriage and fertility rates and increasing urbanisation levels.[1]

Changing working patterns, including non-standard working hours, will increasingly alter demand on mobility systems. In the EU, around 18% of employees are employed in shift work.

Particularly in service sectors, companies are increasingly aligning working hours with market demands, leading to extended opening hours and an increase in night-time work. In the UK, 18% of the population is engaged in some kind of night-time work, which includes the hours between 10 pm and 6 am[2;3] In London, for example, night bus usage increased 170% between 2000 and 2014, while late night (after 10pm) tube ridership has risen at around double the rate of daytime underground trips.[4]
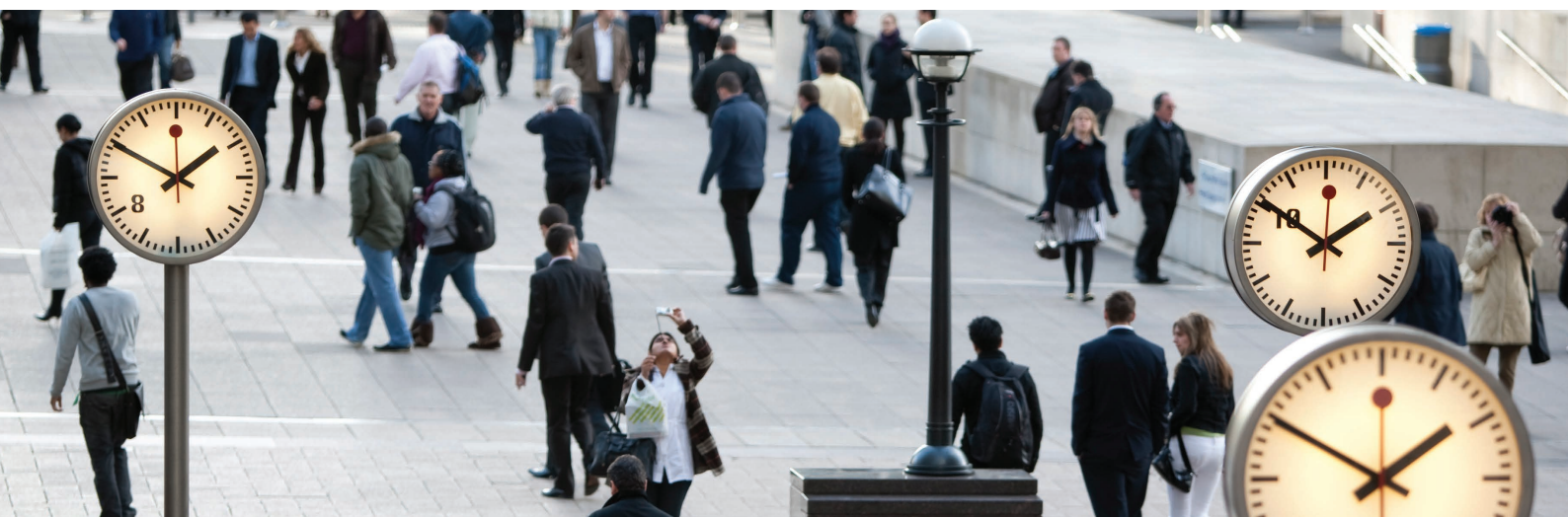
In addition, technological advances are increasingly leading to an anytime, anywhere working culture. Technologies such as the universal availability of broadband, faster connectivity and device innovation are transforming the way we do business. These emerging, more flexible working patterns might ultimately shift demand on mobility systems, change travel patterns and behaviours and the way we access services;[5] potentially leading to greater off-peak travel.

Simultaneously, however, global youth unemployment is estimated at 13.1% – almost three times higher than the adult unemployment rate globally.[6] This also applies to the UK where almost one million young people are unemployed; contrary to adult unemployment, this number continued to grow while the country experienced economic growth. Around one in five young people in the UK are currently seeking work.[7] **Affordable and effective transportation plays a key role in enabling young people to access work and education**. If there is lack of access to affordable and efficient transportation, this can affect the likelihood of finding a job or participating in training opportunities. The WorkWise scheme, for example, aims to tackle this challenge by providing free or discounted tickets to jobseekers, applicable for travel to job interviews or when starting a new job.[8]

Where and how people live and work in the future will greatly influence personal mobility patterns. People will have higher expectations of transport

IN A MORE MOBILE AND CONNECTED ENVIRONMENT, USERS ACROSS GENERATIONS WILL EXPECT SEAMLESS EXPERIENCES TAILORED TO THEIR RESPECTIVE NEEDS.

services, demanding personalised mobility services such as on-demand travel, reliable real-time information and curated modal choice suggestions. These higher expectations will also include a decreasing customer tolerance for risk, including failure of systems. While car ownership will continue to be less important for the younger generation – in the UK, for example, the number of people with driving licences decreased from 48% of 17 to 20 year olds in the early 90s to 35% in 2010[9] – an ageing society will want to stay mobile while having to navigate in a digital world.

Many cities are also actively focusing on decreasing car dependency, transforming the urban environment to encourage alternative modes of transport. Examples include Birmingham's 'Birmingham Connected' strategy which includes the expansion of public transport as well as rerouting of traffic.[10] In Copenhagen, where the main shopping street was closed off for traffic, car use in the area was reduced by 10.7% within one year.[11]

A Rapidly Ageing Society

The United Nations expects the number of people aged 60 years or older to be the fastest growing proportion globally. By 2050, 21% of the global population – over two billion people – is expected to be 60 years old or over, representing a stark increase from 12% in 2015. Developed regions will be most affected by an ageing population; by 2050, Europe will have 34% of its population aged 60 years or over.

In the UK, 31% of the population will be 60 years old or over in 2050, compared to 23% in 2013. Simultaneously, the number of people aged 80 or over will grow from 4.7% to 9.7% while birth rates remain below replacement levels, reaching 1.89 children per woman by 2050.[12] As a result of this older demographic, there will be a shift in the design and choice of urban mobility systems, introducing new user demands and expectations.

Mobility systems will need to accommodate the needs of older people, many of whom will be healthier and more active until later in life, and will also be more mobile.[13] The United Nations estimates the number of people aged 60 years or over living independently – on their own or only with a spouse – to be around 75% in developed countries.[14] In the U.S., for example, 25% of licensed drivers are expected to be over 65 years by 2030.[15]

At the same time however, ageing brings issues in terms of health and mobility, and transport systems will need to be more broadly accessible and make provision for the less mobile, or the hearing and/or sight impaired.

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A healthier older population will increasingly demand easy and accessible solutions that enhance usability of systems, while remaining in control and independent. Transport systems will need to accommodate changing lifestyle habits as older people reduce distance travelled on a regular basis, such as commuting, while increasing travel for leisure.[16] While more and more mobility services will rely on digital infrastructure and services, some parts of an ageing population might experience difficulties navigating the digital world, while others will be more digitally savvy. Simultaneously, the younger generation will transform their travel patterns, away from car ownership towards on-demand services and social networking. Providing transport service offerings that address all age groups and stages of life – from digital natives to an ageing society – will present new challenges to transport providers in utilising the technology available to them to make lives more convenient.

The Rise of the Sharing Economy

Patterns of ownership and the way people are sharing resources are shifting, especially within younger generations. In Western societies, **a new generation of users increasingly favours the sharing of services over product ownership**.[17] This paradigm shift will have fundamental consequences for the design and delivery of urban mobility systems as, for example, consumers are increasingly likely to purchase access to a car rather than buy their own car. In the UK, around 23 million people took part in the sharing economy in 2013 through websites or mobile applications.[18]

Estimates suggest that the five main sectors of the sharing economy – peer-to-peer lending and crowdfunding; online staffing; peer-to-peer accommodation; car sharing; music and video streaming – could be worth £9bn in the UK by 2025, equalling the total global size of these five sectors today.[19]

In developed countries, car ownership and private vehicle kilometres might be reaching saturation as vehicle ownership does not necessarily represent the optimal mobility choice in urban areas. Over the past decade there have been major shifts from ownership towards the use of mobility services, which is fundamentally changing personal mobility.

In the future, it is likely that there will be more and more vehicle sharing concepts, as well as integrated, seamless and intermodal mobility systems, enabled through digital infrastructure.

The sharing of services – including mobility, social and work services – will become a ubiquitous part of everyday lives. **Continually changing lifestyles, preferences and expectations coupled with rapid technological advances will make "usership" more attractive than ownership.**

Car-sharing as an alternative mobility concept is increasingly gaining attention. Globally, 1.8 million people participate in car-sharing schemes, while in Europe, it is expected that car-sharers will number 15 million by 2020, representing a stark increase from 0.7 million in 2011.[20] As one shared vehicle could replace up to 15 privately-owned vehicles, car-sharing will not only have impacts on the provision of mobility systems but also on use of space in urban areas, thus highly influencing urban planning decisions. Furthermore, it is estimated that car-sharing members travel 31% less by car than owners of private vehicles, leading to a significant decrease in CO_2 emissions and less traffic volumes in urban areas.[21]

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Health and Wellbeing

While developed countries suffer less and less from infectious diseases, they are struggling with new types of threats to their populations' health. Obesity and diabetes are becoming more pressing issues, while environmental changes and pollution pose an ever-growing threat to public health. The World Health Organisation suggests that physical inactivity is responsible for around 9% of premature mortality worldwide, representing 5.3 million of 57 million deaths in 2008. Major diseases of affluence, such as coronary heart disease, colon and breast cancer, diabetes and stroke are all linked to physical inactivity.[22] Globally, obesity has reached 'epidemic' proportions, with more than 1 billion overweight adults, 300 million of them obese. In Western Europe, the UK lags behind only Iceland and Malta, with 66% of men and 57% of women overweight or obese.[23]

Cities across the globe will increasingly need to prioritise design and planning considerations in order to actively improve residents' health, and they will need to make walking and cycling much more viable and attractive options. Walking and cycling are great equalisers, reducing the cost of transport and increasing access to jobs and amenities while resulting in immediate environmental benefits. Investment in transport infrastructure and environments that support walking and cycling could pay dividends in terms of public health, and also reduce the increasing pressure on urban transport systems.

THE WORLD HEALTH ORGANISATION SUGGESTS THAT PHYSICAL INACTIVITY IS RESPONSIBLE FOR AROUND 9% OF PREMATURE MORTALITY WORLDWIDE.

Major challenges will include how cities manage the relationship between active and passive transport provision, maximising the contribution transport systems can make to healthy lifestyles. Opportunities for cities could lie in developing a more cohesive relationship between healthcare and transport policy through an integrated approach to transport and public health. Several public health institutions, such as the National Institute for Health and Care Excellence, have already developed recommendations for exploring more active travel options within an urban environment.[24]

Future transport policies developed in line with these principles would pay dividends for local communities' health. An ageing population in particular could benefit from more active transport provision. Copenhagen is a prime example of the successful implementation of cycling infrastructure with 50% of citizens commuting by bike daily.[25] In Zürich, 46% of all journeys are by foot,[26] while cities such as London are investing in wayfinding schemes, aimed at improving the pedestrian experience.

Housing Availability and Affordability

The lack of affordable and quality housing stock is one of the biggest issues facing cities in both the developed and developing world. In London, for example, demand is far outstripping supply, leading to skyrocketing house and rental prices (the average London home costs around £500,000 to buy or £1,160 per month to rent).[27][28]

While renting and owning becomes increasingly expensive in the UK, many cities are facing housing shortages, experiencing large gaps between supply and demand. Manchester, for example, expects requirements for a minimum of 200,000 new homes until 2040.[29] Similar issues are true for other UK cities as well; Birmingham, for example, will need to provide 80,000 new homes within the next 20 years.[30]

It is estimated that the UK construction industry will need to build up to 5.64 million new homes in the next two decades to meet the housing demand of a growing population. Simultaneously, housing construction is slowing, with only 50% of necessary housing stock being built annually in 2013.[31]

The lack of affordable housing could potentially lead to an increasing number of people moving out of UK cities, with implications for commuting patterns and the development of transport systems linking urban and rural areas. From 2008 to 2013, for example, the number of Britons spending a total of three hours or more travelling to and from work soared by 50% to 1.84 million or 9% of the workforce.[32] While this would reduce pressure on existing urban transport systems, mobility providers would experience new challenges of integrating emerging satellite cities or expanding suburban areas into existing systems.

CASE STUDIES

## ROPITS – Self-Driving Robotic Car for the Older Generation

This self-driving robotic car, currently being trialled, will automatically navigate to a pre-set destination using 2D and 3D laser sensors to detect and manoeuvre around objects. ROPITS will weigh around 200 kg and will be powered by lithium-ion-batteries. The target customer are older people and those with physical impairments, as ROPITS are designed to ease and enhance mobility. In addition, ROPITS could become a next-generation 'Segway' for the ever-increasing urban population.

On-demand Ride Sharing Services

Beginning with the launch of Uber in 2009, ride-sharing services have experienced explosive growth worldwide. Uber uses a smartphone app to pair users with private drivers operating their personal vehicles to provide taxi-like on-demand services. Passengers can track the GPS location of their ride via the associated app, and journeys are automatically billed to users' credit cards on file. While specifics of ride-sharing services' offerings vary, the industry as a whole has faced considerable pushback from conventional taxicab companies, who characterise ride-sharing systems as "illegal taxicab operations." Ride-sharing services have also raised regulatory and insurance questions in several markets, with cities scrambling to draft new laws in order to recoup tax revenue from ridesharing.

Pricing has been another area of contention, with several companies instituting "surge pricing" during busy hours, raising questions about the value proposition of the concept.
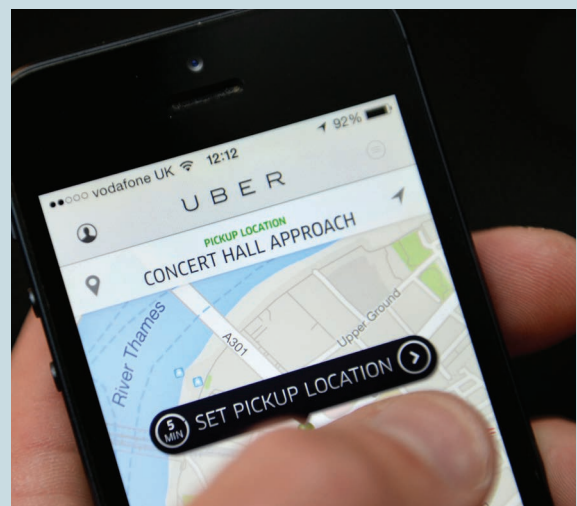
Cycling in Copenhagen

Copenhagen sets a leading example of a city that has promoted self-propelled transport. Through the prioritisation of cycling, as well as implementing obstacles to motorised transport, the number of kilometres cycled has risen by around 30% since 1998. Around 36% of all trips to work or educational organisations in Copenhagen are by bicycle, which amounts to zero CO_2 emissions. This high percentage of cycling is key to the declared goal of making Copenhagen CO_2 neutral by 2025.

Pearl District Portland

Portland's Pearl District, a neighbourhood built along a streetcar line, is a good example of a successful public-private partnership that used transit to promote large-scale redevelopment. As a result of substantial private investment, Portland's 20-year housing goal was met in just 7 years on one-tenth of the projected land.

Night Tube London

From September 2015, Londoners and visitors will be able to travel on the Jubilee, Victoria and most of the Piccadilly, Central and Northern tube lines all night on Fridays and Saturdays. The new service will complement existing 24-hour and night bus services. The Night Tube network will support London's vibrant night-time economy and boost businesses, jobs and leisure opportunities.

It has been estimated 1,965 permanent jobs will be supported by the Night Tube – 265 through direct operation of the service and 1,700 indirectly in the night-time economy. The net additional output produced as a result equates to an extra £360m over 30 years.

FORWARD THINKING CITIES WILL...

> Recognise the key role that transport can play in improving public health – through active travel in particular.

> Recognise that working patterns are changing and leisure travel is increasing, and plan transport provision accordingly – in particular for travel outside peak times on radial routes to urban cores. Also ensure personalised mobility services, with on-demand travel options and real-time information.

> Ensure urban transport systems are ready for an ageing society where older people are healthier for longer but also where greater accessibility for those with impaired mobility becomes integral to transport planning and operations – rather than a 'bolt on'.

> Make walking and cycling much more viable options through improved infrastructure and strategic land-use decisions, to improve public health as well as decrease pressure on transport systems.

> Create better links between urban and rural transport systems, as lack of affordable housing in UK cities could lead to more people moving to the periphery.

> Consider carefully the interplay between the need for new housing and how the transport provision that serves it can be provided in the most sustainable and efficient way.

> Recognise the importance of transport in providing young people in particular with access to education, employment and opportunity – and seek to ensure a more joined up approach between policies on transport, education and young people.

URBAN ENVIRONMENTS

URBANISATION, CLIMATE CHANGE AND THE NEED TO IMPROVE AIR QUALITY PUT PRESSURE ON TRANSPORT SYSTEMS.

Changing Climate and Environment

The wide ranging and complex effects of climate change will continue to pose unprecedented challenges to urban areas. Consequences of climate change will include rising temperatures along with an increase in the frequency and intensity of extreme weather events and rising sea levels. This changing environment may have fundamental implications for the design, operation and maintenance of transport infrastructure, increasing the risk of damage, failure and disruption of services and systems.

In order to avoid the worst effects of climate change, the global temperature increase will need to be halted at a maximum of 2°C. This step will necessitate an 80% reduction of global emissions by 2050 compared to 1990 levels.[33] Although the Department of Energy and Climate Change, for example, projects the total UK territorial emissions to decrease by 53% until 2030, compared to 1990 levels,[34] current estimates suggest there will be a 50% increase in global greenhouse gas emission between 2012 and 2050.[35] Current measures have achieved only a limited impact on greenhouse gas emissions reductions worldwide.

Therefore, more efficient emissions reduction and a focus on resilient strategies are key in dealing with consequences of climate change. As cities are responsible for a large share of these, they are also in a prime position to employ effective emissions reduction, especially in their transport systems.

As a consequence of warming temperatures, global sea levels are expected to rise by 0.26-0.81 metres by 2100.[36] Flooding makes up the largest proportion of natural disasters. With 233 of the world's 633 largest cities situated in areas with high flood risk, sea level rises would affect around 10% of the world's population.[37] Non-coastal cities also face problems of flooding if located beside rivers or in the foothills of mountains in areas vulnerable to intense rainfall or snowmelt.

AS CITIES ARE RESPONSIBLE FOR A MAJOR SHARE OF CARBON EMISSIONS THEY ARE ALSO IN A PRIME POSITION TO EMPLOY EFFECTIVE EMISSIONS REDUCTION.

Sea levels along the British coast could rise up to one metre towards the end of the century.[38] In the UK, flooding represents one of the biggest natural threats, with the South and East of England and Wales particularly at risk due to a combination of rising sea levels and sinking land mass.[39;40] Currently, around 10 million people or 5.5 million properties are situated in flood risk areas, with about half of these under direct flood risk from sea and rivers.[41] In total, infrastructure and resources worth about £120 billion are expected to be at risk from coastal flooding.[42]

Climate change impacts can be exacerbated by large cities, as large built up areas with less vegetation can result in Urban Heat Islands (UHI) which disturb weather patterns. Thus, cities such as London can be up to 10°C warmer in some areas than their surroundings, posing challenges to city systems and public health.[43]

The Royal Meteorological Society, for example, reported an urban heat island spanning nine to ten kilometres from Manchester's city centre.[44]

In 2003, the European heatwave, which was recorded as the hottest summer on record, resulted in 35,000 deaths. Many of these occurred in Europe's major towns and cities.[45] Major infrastructure, such as transport systems, are typically not built to sustain such extreme temperatures. The effects of heatwaves and the UHI effect could result in over-heating, potentially causing structural damage and service disruption. UHI mitigation measures include the implementation of green infrastructure such as green roofs, trees and lighter materials, but also cooling building materials, such as reflecting pavements. It is for example estimated that a 10% increase in green infrastructure in the greater Manchester area could result in areas with 2.5°C lower temperatures.[46]

Increasing Energy and Resource Usage

A growing, more affluent population with increasing consumption needs will lead to rising energy and resource usage and fundamentally challenge ecosystems across the globe. Global resource use is expected to nearly triple to 140 billion tons annually by 2050 assuming current trajectories of consumption and economic development.[47]

The mobility sector is a major contributor to global emissions and overuse of resources.
The transport sector accounts for around 25% of Europe's greenhouse gas emissions, second only to the energy sector. Around 75% of these emissions can be attributed to road transport and 25% of passenger transport emissions are due to urban transport. By 2050, Europe's transport sector is expected to account for 50% of total emissions. By contrast, the EU's target for 2050 is a 60% reduction in transport emissions.[48;49]

In the UK, transport is the largest consumer of energy, accounting for 38% of total energy consumption in 2013, compared to 25% in 1980,[50] while greenhouse gas emissions from the transport sector accounted for 21% of total emissions. The majority of these emissions come from road transport, particularly from private cars and the use of petrol and diesel.[51] Freight mobility accounts for a quarter of petroleum consumption in the UK, demonstrating an important area, besides personal mobility, to implement modal shifts.[52]

IN THE UK, TRANSPORT IS THE LARGEST CONSUMER OF ENERGY, ACCOUNTING FOR 38% OF TOTAL ENERGY CONSUMPTION IN 2013, COMPARED TO 25% IN 1980.

It is estimated that the energy use in UK's transportation sector will decrease slightly to 2020, despite a projected 30% increase in road traffic. This is mainly attributed to efficiency improvements due to existing policy measures. In the long-term, however, vehicle efficiency improvements will be marginally offset by the continued rise in vehicle kilometres driven by economic and demographic growth.[53]

The dual necessity to reduce emissions while accommodating an ever-growing mobility demand will likely spark innovation in the sector, fundamentally transforming the operation and development of mobility systems and infrastructure. Efficiency and finding alternatives to fossil resources become key issues. Changing transport habits could fundamentally reduce emissions through, for example, shifting shorter journeys to active forms of transport and favouring public transport over private vehicles.

Increasing Population and Urbanisation

The global population is expected to reach 9.6 billion in 2050, adding 2.4 billion people from 2014 levels. This development will increase global mobility demand. While Europe's population will stay fairly constant, with some countries experiencing population decline, the UK will have added 10 million people to its population by 2050, reaching 73 million people.

The UK's population growth will be mainly due to immigration and slightly rising birth rates. Despite Britain's birth rates remaining below replacement levels – 1.89 children per woman in 2050 – they are still considerably higher than in many other major European countries.[54]

Additionally, an increasing global urbanisation rate will continue to challenge already strained urban systems and infrastructures. **A growing and more prosperous number of urban dwellers will lead to an increase in individual mobility demand, requiring urban areas to be far more efficient.** Urbanisation rates, increasing traffic volumes and pressure on infrastructure capacity all pose unparalleled challenges on urban mobility systems. Simultaneously, denser urban areas may offer opportunities for innovative and interconnected mobility solutions.

Currently, about half of the global population is living in urban areas. By 2050, this number is estimated to reach 66%. By then, 6.4 billion people will be living in urban areas, a considerable increase from 3.9 billion urbanites today. Currently, urban travel makes up 64% of all miles travelled. It is expected that the amount of travel within urban areas will triple by 2050.[55]

In the UK, urbanisation levels are expected to reach 89%, equalling a 0.3% annual increase from 2010 to 2050. By then, 65 million people will be living in cities, compared to 8 million in rural areas. The UK will experience a higher urbanisation rate compared to the global rate of 66% and the Europe average of 82%.[56]

Increasing urban mobility and congestion will require alternative mobility options as mobility demand is highly variable in cities throughout the day. Greater urbanisation will require strategies to ensure that this does not lead to greater road congestion – particularly at peak times. This will pose increasing challenges to urban mobility systems as urbanisation continues. Furthermore, with more and more people living in cities, plans to reduce urban mobility will become increasingly necessary.

IN THE UK, URBANISATION LEVELS ARE EXPECTED TO REACH 89%, EQUALLING A 0.3% ANNUAL INCREASE FROM 2010 TO 2050.

Infrastructure under pressure

The International Transport Forum estimates global passenger mobility will increase three to four times by 2050, compared to 2000, posing increasing challenges for existing transport infrastructure. At the same time, transport infrastructure will need to cope with increasing freight volumes and growing demand for transport solutions that are seamless, faster, and more reliable and environmentally friendly. By 2050, freight volumes are expected to increase by 2.5 to 3.5 times.[57]

If recent demand trends continue, motorised vehicle numbers are expected to increase 3% per year globally until 2030, while Europe will experience a slightly lower growth rate of 1% per year.[58] The number of trips by private motorised vehicles is expected to grow by 80% from 2005 to 2025, and in the same time, trips made by public transport are expected to increase by 30%.[59]

However, although many Government's continue to forecast growing car use there is also evidence to suggest that since 2000 a plateau in vehicle mileage can be seen across many developed countries – including the USA, Canada, Japan, France, Germany and the UK. The reasons for this could include, rising fuel prices and falling incomes, as well as increasing urban density and changing attitudes. At the same time in many cities we have seen growing use of urban transit systems as well as cycling.

With their limited ability to increase infrastructure capacity, cities will need to optimise the use of existing capabilities and implement technological innovations to transform the operation of urban mobility systems as a whole.

THE COST OF MAINTAINING, UPGRADING AND EXPANDING UK TRANSPORT INFRASTRUCTURE IS ESTIMATED TO ACCOUNT FOR £350 BILLION OVER THE COMING 20 YEARS. THIS REPRESENTS AN INCREASE BY 45% IN ANNUAL SPENDING SINCE 2000.

In addition to cities' challenges in their ability to increase infrastructure capacity, they are increasingly faced with deteriorating transport infrastructure and pressures to secure sufficient funding. The OECD has estimated that around US$50 trillion would be needed worldwide in the period to 2030 to satisfy the global demand for infrastructure.[60] The cost of maintaining, upgrading and expanding UK transport infrastructure is estimated to account for £350 billion over the coming 20 years. This represents an increase by 45% in annual spending since 2000. In light of these required investments, the UK will experience a public-sector funding gap of about £100 billion until 2030.[61]

The need to invest more in inadequate and ageing infrastructure comes at a time when many governments are highly indebted and face competing demands for their scarce resources. There is also a need to adapt existing and future transport infrastructures to changing technology and usage, such as new fuel technologies and an increasing electrification of transport.

Incentives and pricing solutions can improve the capacity of existing transport infrastructure. Cities such as Singapore, London, Stockholm and Milan have introduced successful congestion charging measures. Other measures, such as time-based charging variations, can help flatten peak-time travel by making it more expensive to travel at peak times.

Congestion and Air Quality Challenges

Overcrowding and congestion are increasingly causes of deteriorating air quality and other negative externalities in cities including economic impacts such as costly delays. For cities to remain economically competitive, effective and efficient mobility systems are key.

In recent years, it has become clear that cities will not be able to build their way out of congestion through more and more infrastructure. Instead they need to acknowledge the limitations of current systems and invest in new and innovative transport solutions. For example the economic costs of urban congestion in the US are expected to reach $186 billion each year by 2030, a 50% increase from 2013[62;63] Within Europe, the UK experiences one of the highest motorway usages – 113 million passenger vehicle kilometres are driven annually per kilometre of motorway.

In comparison, this number is only 47 million in Germany and 39 million in France.[64] Traffic congestion costs the UK economy £4.3bn a year; this represents economic congestion costs of £491 per car-commuting household.[65] Some of the external costs resulting from congestion include increased air and noise pollution, more accidents, greater driver stress, increased travel time and increased business costs.

The United Nations estimate that each year, over one billion people are exposed to air pollution and that around one million premature deaths are related to urban air pollution. In terms of GDP, urban air pollution is expected to cost developed economies 2% of GDP while this number reaches 5% in developing countries.[66] Additionally, it is estimated that around half the global urban population is subjected to air pollution levels 2.5 times greater than the maximum levels recommended by the World Health Organisation.[67]

THE UNITED NATIONS ESTIMATE THAT EACH YEAR, OVER ONE BILLION PEOPLE ARE EXPOSED TO AIR POLLUTION AND THAT AROUND ONE MILLION PREMATURE DEATHS ARE RELATED TO URBAN AIR POLLUTION.

MANY CITIES ARE INCREASINGLY LOOKING INTO MEASURES TO REDUCE CONGESTION AND SIMULTANEOUSLY IMPROVE THEIR AIR QUALITY. HAMBURG, FOR EXAMPLE, HAS ANNOUNCED AMBITIOUS PLANS TO GO CAR-FREE BY 2025.

Air pollution in EU cities causes 310,000 premature deaths/year and health costs of 427-790bn/year.[68] These numbers, combined with the fact that cities are responsible for around 70% of global greenhouse gas emissions, highlight the necessity to reduce GHG emissions, and increase policy measures to cleanly and efficiently power mobility in cities. Many cities are increasingly looking into measures to reduce congestion and simultaneously improve their air quality.

Hamburg, for example, has announced ambitious plans to go car-free by 2025. The city aims to become greener, healthier and more liveable. Plans to achieve this include the creation of an extensive network of pedestrian and cycle paths in combination with a network of green infrastructure. Positive side effects are said to include reduced emissions and improved resilience to extreme weather risks.[69]

CASE STUDIES

Hiriko – Modular and Foldable Vehicle Concept

Hiriko, a foldable, modular, electric vehicle was developed in response to increasing urban traffic volumes. This project by MIT is geared towards urban car-sharing. Hiriko is the first fully electric, space-saving car which can be easily folded for parking. Additionally, the modular structure allows for an easy change of body panels and interior elements. From 2014, Hiriko has been used by car-sharing provider Flinkster in Berlin, a subsidiary of Deutsche Bahn.
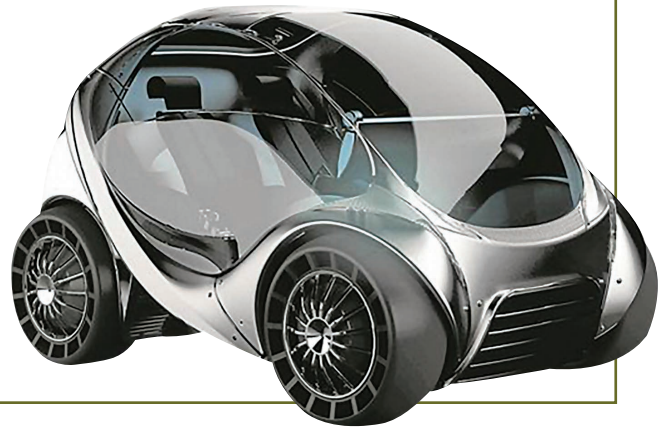
Transitmix

Transitmix is a data-driven planning tool for urban bus transit. The platform has successfully engaged with local authorities and individual users to create over 50,000 transit maps in 3,600 cities around the world. Users can suggest a new bus line, or change of an existing bus route, timetable and service frequency on a city map. This tool allows users to share insights and makes stakeholder and citizen engagement simpler.

By visualising city's transit data and wider city data together, Transitmix provides a more tangible way to demonstrate how potential bus services work, identify service gaps, and assess the impact of changes. Transitmix improves urban transport planning processes, and could potentially support cities in addressing urban challenges, such as social inequality and economic prosperity.

## CarGo Tram Urban Logistics System

This innovative logistics solution supplies parts to Volkswagen's Transparent Factory in a busy urban centre, efficiently moving material over existing passenger infrastructure. Volkswagen's Transparent Factory was designed to be integrated with the cargo transit centre in the city of Dresden.

The CarGo freight tram system was developed as an innovative logistics concept wherein existing tramways are utilised to distribute material, component parts and products to the factory. This assures a highly efficient, continuous flow of resources by linking the factory to necessary production supplies without the need for specialised delivery infrastructure.

SFpark

The City of San Francisco launched a smart parking pilot project, SFpark, in 2011, by using smart parking meters to manage the supply and demand of on-street parking. To further improve on-street parking availability on each block in pilot areas, SFpark uses demand-responsive pricing to change parking fees based on the availability of parking space by time of day and block.

This helps the city to open up parking space and deal with some key urban challenges, including traffic congestion and carbon emissions. In 2014, most drivers were able to find parking space within an average 6.5 minutes in pilot areas. The greenhouse gases generated by circling for parking have been reduced by 30%, and double parking reduced by 22% in pilot areas.
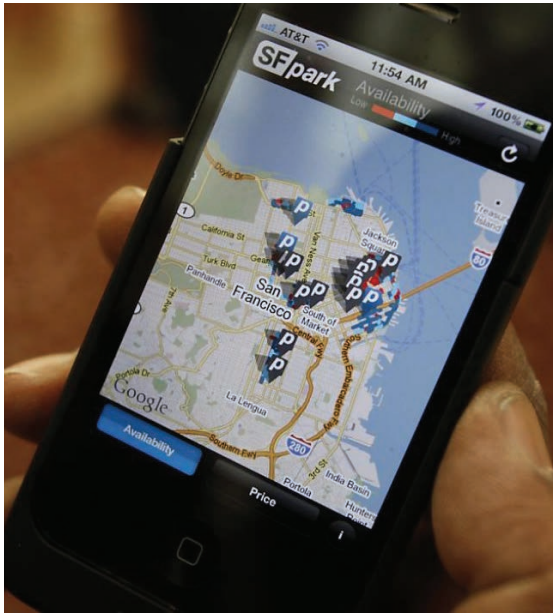
Copenhagen Smart LED Transit Lighting Project

Copenhagen has invested heavily in transforming its lighting and infrastructure systems into a vast network of real-time sensors, allowing efficiencies in everything from bicycle commuting to waste collection. The shift began with the "Green Wave" cyclist-sensing timing system, first implemented in 2007. By timing streetlights to prioritise cyclists over vehicles, and installing sensor-responsive roadside LED lights to help cyclists set a pace that would maximize intersection throughput, the city reaped both health and economic benefits from a more efficient commuting experience. Recently the sensor network has been expanded, allowing dimming of streetlights in low-traffic areas, predictive assessment of road-salting demand before snowstorms, and traffic lights that can alert lorry drivers to timing changes via a smartphone app, saving fuel and time. Several cities worldwide are implementing components of Copenhagen's sensor practices.

FORWARD THINKING CITIES WILL...

> Put more emphasis on maintenance, renewal and resilience to ensure that transport infrastructure and provision can cope more effectively with a changing climate.

> Include effective measures to reduce emissions in the design of future transport systems such as incentives and pricing solutions, lower energy use, increased efficiency and promotion of public transport over private vehicles.

> Consider the benefits of green infrastructure as a mitigation measure for climate change consequences, and to improve the health of citizens.

> Place greater emphasis on facilitating low carbon, electric and low emission vehicles and the promotion of active travel, especially walking and cycling.

> Ensure the coordination of transport and land use planning so that denser urban development can be served by mass transit systems. Densification enables more efficient, interconnected mobility solutions which could alleviate congestion and improve air quality.

SYSTEMS AND TECHNOLOGY

ADVANCES IN TECHNOLOGY AND INCREASED DIGITAL CONNECTIVITY MAKE TRANSPORT INFRASTRUCTURE SMARTER AND MORE EFFICIENT.

Big Data and the Internet of Things

The drive towards smarter transportation systems will lead to more efficient and sustainable urban centres. Increases in computer and processing power will enable this shift and will lead to more effective, real-time use of big data. Big data and the Internet of Things will enable communication between different modes and with the wider environment, leading to truly integrated and inter-modal transport solutions that maximise efficiency gains.[70] Big Data will be worth US$122bn in the automotive industry alone by 2025, with 70-80% of cars expected to be connected to the internet.[71]

It is estimated that there will be a 4300% increase in annual data generation by 2020, and more than a third of the data produced will live in or pass through the cloud.[72] Cloud-based services will become more widespread driven by the uptake of smarter mobile devices and faster connectivity. By 2016, it is expected that the penetration of smartphones in the UK will reach 90%,[73] and that the big data market will benefit the UK economy by £216 billion and create 58,000 new jobs before 2017.[74]

NEW MOBILITY SERVICES ARE BEGINNING TO ADDRESS TRANSPORT DEMAND ISSUES BY BUILDING ON DATA FROM PHYSICAL INFRASTRUCTURE AND SERVICES.

Smart and Connected Mobility

In order to provide sufficient transport capacity for the growing volumes of goods and people, intelligent and integrated transport solutions will become essential. In addition to growing demand, people's expectations of seamless and integrated mobility are increasing and their transport needs are evolving.

Smart communications technology will become one of the key infrastructures of future cities, helping to improve the efficiency and coordination of systems. Improving connectivity and smarter devices will enable cloud-based services to become widespread and more user-friendly. Smart technology will enable real-time information for travellers and more integrated services. Interoperable tickets, valid for trains, buses, car-sharing schemes and bicycles, could encourage intermodal travel by providing seamless connections to other modes.[75]

Integrated ticketing and payment systems, such as the use of smartcards, phones or bank cards as a single device to pay for journeys, linked to personalised real-time travel information, further simplify inter-modality and improve customer experience.

Greater use of Intelligent Transport Systems (ITS), will enable better traffic flows, more accurate road pricing, and enhanced capacity and safety. ITS encompasses a range of technologies used to manage transport – from sensors and surveillance to ticketing and payment systems – that are used to monitor and manage travel conditions.

ITS equipment continuously generates new data about the transport network, and enables operators to make real-time interventions to manage traffic and travel.[76] Investment in smart transportation solutions, such as intelligent traffic-management systems or smart charging management, will reach US$5.5 billion annually by 2020, a compound annual growth rate of 20% between 2012 and 2020.[77]

SMART COMMUNICATIONS TECHNOLOGY WILL BECOME ONE OF THE KEY INFRASTRUCTURES OF FUTURE CITIES, HELPING TO IMPROVE THE EFFICIENCY AND COORDINATION OF SYSTEMS.

The growing reliance on smart technologies and systems, however, can give rise to issues of safety and security, especially in the form of cyber-attacks. In 2014, the UK was ranked first in Europe for targeted cyber-attacks and second globally.[78] In addition, use of data gives rise to concerns around privacy and the secure handling of data, including personal and financial details. One of the greatest risks to transportation organisations is the combination of both physical and cyber-attacks on their infrastructure.

It has been demonstrated, for example, how easy it is to hack into the computerised features of cars such as the Toyota Prius, disabling the brakes and turning the steering wheel. The increased risk is the result of the surge of social media applications, online technologies and self-service user terminals, and increasing threats of terrorist attacks.[79]

Shift to Mobility as a Service
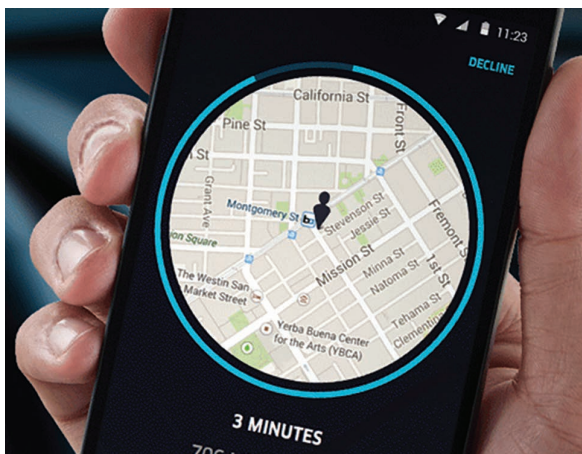
Traditional models of ownership are changing, especially within younger generations. For example, **the trend towards a shared economy of service provision rather than product ownership means that consumers are increasingly likely to purchase access to a car rather than buy their own car**. Services like Uber and Lyft are evidence of the shift from providing mobility as a product to providing mobility as a service. Mobility services could help counter growing car ownership and improve affordability and efficiency.

Access to cars, car sharing and taxis are likely to become part of a wider trend towards the retailing of packages of mobility. So people can use smart devices to access information and make payments for the transportation that meets their particular needs and budget. This could include access to car hire, taxis, public transport and bike hire.

The retailing of mobility packages could also become increasingly detached from the operation of those services with a race between increasingly large corporate entities to be the 'Amazon of mobility' in a global market of enormous value.

A wide range of players are likely to enter this space – including large automobile, energy, telecoms companies, the internet giants alongside existing public and private sector public transport providers.

There are also scenarios where the public sector could lead by adding taxi, car share and car hire options to a core public transport offer – perhaps through strategic alliances with the automobile industry. This appears to be the objective for many urban areas in countries like Germany and Austria. In other countries there could be competing mobility offers led by different private sector providers or alliances.

TRADITIONAL MODELS OF OWNERSHIP ARE CHANGING, ESPECIALLY WITHIN YOUNGER GENERATIONS.

Growth of Electric and Autonomous Vehicles

While fossil fuels have dominated the ground transportation sector for the last century, **it is expected that electricity will play an increasingly important role in both private and public transportation in the future**. It is likely that most vehicles will be electrified to some extent, and well-developed networks of chargers to support battery electric vehicles will be vital.[80] Wireless charging infrastructure could also be embedded in the road, providing induction charging for electric vehicles on the go.

Advances in battery technology and lowered costs will also encourage uptake of electric vehicles. Auto manufacturer Tesla is building a "Gigafactory" in Reno, Nevada, which will be the world's largest lithium-ion battery factory.

AUTO MANUFACTURER TESLA IS BUILDING A "GIGAFACTORY" IN RENO, NEVADA, WHICH WILL BE THE WORLD'S LARGEST LITHIUM-ION BATTERY FACTORY.

Through economies of scale, the Gigafactory is expected to drive down the per kilowatt cost of the company's own lithium-ion car batteries by more than 30% in its first year of production in 2017.[81] Tesla has also provided its own 'supercharger networks' in the UK, Europe and the US to enable Tesla drivers to recharge for free, thus reducing one of the biggest obstacles to the widespread adoption of electric vehicles: range anxiety.[82]

At the Smart Cities Research Group at MIT Media Lab, an innovative concept has been developed for replacing traditional cars with electric vehicles in urban areas while dealing with restricted space. The concept, called the City Car, is a small, folding, space-saving electric vehicle. Micro Electric Vehicles could assist in solving the first and last mile issue.

Through full integration with existing transport infrastructure, they could bridge the gap between home or work and public transport stations, thus getting people to use public transport who would not do so otherwise. Through their space-saving ability, they could ease pressure on transport infrastructure and parking space provision while minimising pollution in highly congested city centres. A prototype that emerged from this research is the Hiriko Fold, developed by the Hiriko Driving Mobility Group.[83]

There are synergies to be realised between the development of smart electricity grids and smart electric transport systems.

A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. Smart grids combined with smart electric cars means that electricity can be stored in cars at times of over-supply and fed back into the grid when needed. The same is true for electrified public transport systems. This is particularly useful given peaks and troughs that come with renewable energy sources of sun and wind. It also contributes to wider energy efficiency and the speed at which renewable and clean energy can make up a higher proportion of power generation for the grid. By 2014, 459 smart grid projects were launched in the EU since 2002, spread over 47 countries.[84]

However, regulatory frameworks will need to adapt to changing requirements in order to allow for, for example, changing of tariffs to incentivise the uptake of electric vehicles.[85]

DRIVERLESS CARS ARE BEING TRIALLED ON UK ROADS FOR THE FIRST TIME IN 2015. TRIALS ARE TAKING PLACE IN BRISTOL, MILTON KEYNES, COVENTRY AND GREENWICH, LONDON.

The Internet of Things will enable the rise of technologies such as intelligent vehicles that can measure the latest traffic, road and weather conditions. These vehicles will be able to communicate with each other and the wider environment,[86] transmitting their speed and direction and warning other vehicles about traffic and safety hazards.

Wireless sensor networks combined with ultra-low power sensors will make it possible to monitor the condition of a wide range of structures like bridges or tunnels, alerting authorities to weaknesses or disrepair.[87] Until 2020, the amount of internet-connected cars is expected to increase 30% each year leading to 20% of all cars being internet-connected by then.[88]

Autonomous vehicles, enabled through increased connectivity, could fundamentally change urban mobility and have a number of implications for governments, including rethinking transport policies and existing regulatory frameworks, the role of urban infrastructure, auto licensing and traffic enforcement, parking and taxi provision.[89]

Fully automated vehicles will open up new markets for automotive companies to sell to older people, or those with physical or mental impairments. Driverless vehicles will likely cause changes to the infrastructure of cities, as roads could be made narrower and roadside signage could be reduced. As driverless cars will travel safely in closer proximity to other vehicles, the capacity of existing infrastructure could be improved.[90]

> **UNTIL 2020, THE AMOUNT OF INTERNET-CONNECTED CARS IS EXPECTED TO INCREASE 30% EACH YEAR LEADING TO 20% OF ALL CARS BEING INTERNET-CONNECTED BY THEN.**

Driverless cars are being trialled on UK roads for the first time in 2015. The UK Government has committed £19 million to fund to these trials, in the hope that they will place the UK at the forefront of driverless technology.[91]

Autonomous vehicles could also provide efficiency gains. Over the past few years, Volvo has been testing self-drive vehicle convoys, where cars are wirelesses linked to each other and follow a lead vehicle controlled by a driver. Using wireless communication and autonomous control, the vehicles in the platoon simulate the lead vehicle, mimicking its actions.

Vehicle convoys can reduce congestion and cut fuel consumption. A complete uptake of driverless vehicles will depend on the development of comprehensive regulatory frameworks as well as public trust around security and safety issues.[92] An incremental uptake of autonomous vehicle technologies is more likely. This includes steps to automation within vehicles but also the use of autonomous vehicles within a confined area. Applications could include taxis or buses operating on pre-set routes or within a defined location.[93]

More Efficient Urban Logistics Systems

Urban logistics systems form the backbone of a functioning city and economy providing the goods and materials needed to successfully operate a city. The way goods and services are delivered has wide ranging implications for urban life, including congestion, safety, noise and air quality considerations.[94]

Congestion and environmental pressures are leading to the development of alternative and more efficient logistics systems to reduce freight in city centres. Some of these last mile logistics solutions include electric cargo bikes, underground freight pipelines, delivery lockers at stations, and 'closed loop' systems where vehicles making inbound deliveries into the city pick up outbound recyclable waste for disposal and returns from retailers. Other reduction measures, such as consolidation centres, also aim to lessen the impact of freight movement in cities.

Urban freight from heavy and light duty vehicles is estimated to make up at least 15% of traffic in urban areas.[95] In London, freight accounts for around 17% of all road traffic, and by 2031, this is forecast to grow by 25%.[96] As part of a £750m regeneration of Regent Street, Arup was commissioned to develop measures to reduce the volume of delivery vehicles around Regent Street. To improve overall retail logistics efficiency, Arup proposed the use of a retail consolidation centre, the first in the UK to make use of existing operational facilities.

Since the scheme has been implemented there has been an 80% reduction in lorry movements associated with retailers on Regent Street.[97]

The electrification of logistics systems can also offer environmental and efficiency benefits. FREVUE (Freight Electric Vehicles in Urban Europe), an EU funded project, is looking into the electrification of supply chains in eight cities to demonstrate the benefits of electric vehicles operating last mile freight movement in city centres. Likewise, DHL is running trials to utilise unmanned aerial vehicles for city's first and last mile delivery challenge.[98]

Furthermore, manufacturing might increasingly return to cities; 3D printing, or additive manufacturing, is a revolutionary technology that could lead to reduced transport of certain goods, which could be printed on site or closer to consumers. It is expected to transform the supply chain, reducing the need for mass-produced manufacturing, transportation and storage. Urban areas need to ensure that their planning policies seek to ensure that all major new distribution parks are rail (or water) connected and seek to ensure that 'last mile' deliveries are completed by low/zero emission modes where possible.

CONGESTION AND ENVIRONMENTAL PRESSURES ARE LEADING TO THE DEVELOPMENT OF ALTERNATIVE AND MORE EFFICIENT LOGISTICS SYSTEMS TO REDUCE FREIGHT IN CITY CENTRES.

Opportunities and Challenges for Cities

With more data available from a variety of sources – anonymised mobile phone data, CCTV systems, connected vehicles and infrastructure – the information available to make **better informed decisions about the operation and planning of transport systems** improves exponentially. For example in managing flows following service disruptions or in forecasting the impacts of infrastructure changes to urban transit networks or highway capacity.

These new sources of data are often also far cheaper than traditional methods of gathering travel data like manual traffic counts or bespoke computer models. There are also interesting **opportunities to democratize and open source transport planning** through placing data and strategies in the public domain and allowing the public to use the data to explore, investigate and make judgements on how transport challenges could best be solved. There can however be institutional and commercial issues around the compatibility of data, as well as who pays for and holds the data and for what purpose.

Public sector authorities may lack the capacity to invest in data collection and analysis, or different parts of the public sector may be collecting data in ways which do not align. Whereas the private sector may be able to invest in data systems but may wish to retain and use the data in a way that suits its commercial interests – for example in order to protect or develop a monopoly position by using it to drive planning or operational policies that suits its interests.

However, overall there are opportunities to plan and operate transport systems far more efficiently and at less cost through better use of data. In the UK, a number of ITS projects have already delivered value, including increasing bus patronage in Bristol by 10%, reducing accidents for pedestrians by 21%, and reducing the impact of floods by warning of closed roads via twitter.[99] In Sao Paulo, the city government is trialling the use of data analytics to better manage the city's bus fleet. The concept is based on real-time ridership data.[100]

The local regulatory and policy framework may also find itself rapidly overtaken by new and disruptive market entrants and technologies – from electric, connected and autonomous vehicles to new mobility options (from Uber-style operations through to Segway-style mobility options). All of which can have safety, social inclusion, environmental and urban realm implications.

City authorities will need to think about to what extent they wish to be proactive in shaping the context in which these innovations are taken up. Including how they respond to both national policy and legislation but also over the local legal and regulatory framework that they control. In doing so there may be opportunities to withdraw from certain areas of provision (for example in the provision of consolidated transport information to the public as independent apps become a primary source).

In other areas there could be opportunities to take advantage of emerging technologies to improve efficiencies (for example in coordination of transport fleets across the public sector).

Elsewhere they may be a need to be an adept and agile player in these new spaces so that, for example, the advantages of private sector investment in data collection and analysis doesn't lead to data that is effectively privatized for monopoly corporate gain. Or to seek to ensure that Uber-style developments in the taxi market does not lead to discriminatory provision and that taxis complement core urban public transit routes rather than contribute to congestion.

Smart ticketing by smart media (be it cards or via smart devices) offers the opportunity for cities to not only offer citizens access to all modes of transport to make their journeys but also to add on civic functions and benefits (like access to cultural and health facilities).

SMART TICKETING BY SMART MEDIA (BE IT CARDS OR VIA SMART DEVICES) OFFERS THE OPPORTUNITY FOR CITIES TO NOT ONLY OFFER CITIZENS ACCESS TO ALL MODES OF TRANSPORT TO MAKE THEIR JOURNEYS BUT ALSO TO ADD ON CIVIC FUNCTIONS AND BENEFITS.

However, there are choices to be made as if the cities do not drive the mobility offer that can be provided by smart means then it is likely that the private sector will offer either fragmented, confusing and competing offers – or that private monopolies will emerge. Cities that drive smart mobility offers will be in a position to align these offers with wider policy goals – such as the take up of electric hire cars, promotion of bike hire schemes, greater public transport patronage and add-in civic benefits as well as opportunities to raise funding which can be ploughed back into transport investment.

City economies can also benefit from promoting and enabling green and smart transportation technologies. Less polluted cities are more attractive places to live, work and invest in. New transport technologies also create new businesses and entrepreneurs – from cycle logistics companies to electric vehicles.

CASE STUDIES

Smile Vienna

Vienna has successfully tested a Smile app that makes it possible to use and pay for all forms of local public transport, taxis as well as bike and e-car hire. The app provides information on options by mode, time, price and CO_2. Once the option, or combination of modes, has been selected, the app facilitates payment. 75% of users of smile said they were satisfied or very satisfied and 48% of users said that since using Smile they use public transport more often and 21% used their car less frequently. The Smile trial is part of the Vienna authority's wider smart city programme which aims to improve quality of life, reduce car dependence and cut energy use.

Berlin Smart Grid / Smart Transport

Germany's renewable energy sector is among the most innovative and successful worldwide. Power generation from renewable energy sources in Germany increased from 6.3% in 2000 to about 30% in 2014. Germany also wants to be a leading market for electric vehicles, with a goal of one million registered electric vehicles (including hybrid) by the year 2020. Brandenburg (which includes Berlin) in 2010, was already able to meet approx 70% of its total electric energy demand using renewable energy sources. In Berlin this all comes together on the EUREF campus.

Based on a former gas works the site brings together academia with small and large companies working on both smart grid and electric transport technologies. The campus uses on-site solar and turbine power managed by sophisticated IT to power the electric vehicles that are being developed. There is a long series of win-wins for Berlin from all of this – a greener, cleaner and more attractive city for residents and visitors and becoming a hub for new green technologies and industries both large and small.

Cyclelogistics electric cargo bikes

According to the EU funded Cyclelogistics project, 51% of all deliveries in European cities could be made by bikes and cargo bikes, while research by the German Institute of Transport found that e-cargo bikes could take care of 85% of deliveries in Berlin. The main aim of Cyclelogistics is to reduce the CO_2 emissions, urban air pollution, noise pollution and traffic from freight vehicles in urban areas by encouraging delivery companies to use smaller, near zero emission vehicles. This can also reduce costs. In the Netherlands, global delivery firm DHL has replaced 33 delivery vans with 33 cargo bikes, saving around 152 tonnes of CO_2 and £340,000 per year.

UK Autodrive

Arup, in collaboration with the Transport Systems Catapult, Cambridge University and the Automotive Council, is working on a futuristic autonomous pod system for the city of Milton Keynes. The scheme will see autonomous pods, large enough to accommodate two people, run on special pathways in the city. It is envisaged that by 2017, a hundred fully autonomous pods will operate in the same space as people, using sensors to avoid obstacles. In Coventry, driverless Jaguar Land Rover and Ford vehicles will be trialled on roads from early 2016. UK Autodrive is a three-year programme led by Arup.

FORWARD THINKING CITIES WILL....

> Think about the implications of new technologies and disrupters on their regulatory role; the implications for the services they currently provide and the people who use them; and how best they can adapt to and maximise the benefits of successive waves of change rather than be swamped by them.

> Be at the centre of determining the mobility offers that will be delivered by smart means in order to promote wider goals – greater public transport use, e-vehicles and active travel. And also to realise the opportunites for civic add-ons as well as generating funds for investment.

> Make the connections between power generation and smarter, greener transport including by linking smart electricity grids with smart, electric transport.

> Realise the benefits that big data brings to transforming the cost and efficiency of transport planning and operation.

> Seek to be centres for the implementation of new green and smart technologies and approaches on transport – because they bring with them more attractive urban realms and more dynamic local economies – all of which attracts people and investment.

> Look to ensure that long haul freight accesses cities by rail (or water) where possible and that last mile deliveries are by low or zero emission vehicles.

> Consider the increasing adoption of electric, connected and autonomous vehicles which will likely cause changes to the infrastructure of cities, including changes in transport policy or the provision of advanced charging networks.

> Be aware of issues of safety and security, especially in the form of cyber-attacks, related to a growing reliance on smart technologies.

CITIES AND POLICY

MORE POWERS ARE DEVOLVED TO CITIES AND CITY REGIONS WHICH RESULTS IN MORE INNOVATION AND LEADERSHIP IN RESPONDING TO URBAN CHALLENGES IN LOCALLY APPROPRIATE WAYS.

More Power Devolved to Cities

In order to achieve the most benefit for local transport systems, the right decisions need to be made at the right level. Currently, transport decisions are highly centralised in the UK; outside London, local governments experience a lack of power about transport decisions as well as funding shortages.[101]

There is a case to be made for strong city leadership to implement change in a city's transport network. Especially in the transport sector, bringing power closer to those affected, could result in significant benefits.[102]

Greater Manchester, for example, was able to develop a devolution agreement with Government that gives the region more power and resources, thus enabling local decision-making processes to develop transport infrastructure in the region.[103]

An example of successful urban governance in respect of transport is Bogotá, Colombia, where then Mayor Enrique Peñalosa transformed the city's mobility infrastructure by giving investment priority to pedestrians, followed by bicycle facilities, public transit, and lastly cars. The number of people cycling rose from almost nothing to over 5% of the city's population.[104]

CURRENTLY, TRANSPORT DECISIONS ARE HIGHLY CENTRALISED IN THE UK; OUTSIDE LONDON, LOCAL GOVERNMENTS EXPERIENCE A LACK OF POWER ABOUT TRANSPORT DECISIONS AS WELL AS FUNDING SHORTAGES.

A recent government report on the future of urban governance in the UK to 2065, concluded that metropolitan governance structures and powers will need to allow for planning, investment and service delivery on a regional scale.[105] In order to be adaptable and resilient in the future, cities will need bold and capable leadership, indeed with growing urbanisation and greater devolution 'city states' will gain greater confidence to set the pace in developing their own innovative and independent policies – often moving faster than national governments. For example in moving to less car-centric transport policies, road user charging mechanisms or in their commitment to tackling climate change.

IN ORDER TO BE ADAPTABLE AND RESILIENT IN THE FUTURE, CITIES WILL NEED BOLD AND CAPABLE LEADERSHIP, INDEED WITH GROWING URBANISATION AND GREATER DEVOLUTION 'CITY STATES' WILL GAIN GREATER CONFIDENCE TO SET THE PACE IN DEVELOPING THEIR OWN INNOVATIVE AND INDEPENDENT POLICIES.

Planning Policies and Demand Management

Demand management is one way to get more capacity out of existing infrastructure. A successful strategy was implemented during the 2012 Olympic Games in London, where more than a third of Londoners changed their transport habits to avoid congested hotspots. This was achieved both through a clear communication strategy and effective journey planning tools.[106] Flattening peaks through pricing and flexible working is another way to help ease strain on the transport system. Ultimately, reducing the overall need to travel remains a central objective of urban planning practice.

Transport is a derived demand; it is used primarily to achieve some other goal. Therefore demand management is only one part of the solution. Transport and planning policies need to be more integrated to help realise efficiencies or improve service delivery. Britain has historically lacked integration of urban regeneration, transport planning and land use policies, which has posed challenges for the transport sector.

DEMAND MANAGEMENT IS ONE WAY TO GET MORE CAPACITY OUT OF EXISTING INFRASTRUCTURE. A SUCCESSFUL STRATEGY WAS IMPLEMENTED DURING THE 2012 OLYMPIC GAMES IN LONDON, WHERE MORE THAN A THIRD OF LONDONERS CHANGED THEIR TRANSPORT HABITS TO AVOID CONGESTED HOTSPOTS.

Incentives and Pricing Solutions

An important part of implementing policies is for governments to provide the right incentives to change behaviour. For example, governments could tax the activities they want to discourage and not tax the activities they want to encourage. One way to help decrease congestion and emissions is to encourage people to take public transport over travelling by private vehicle.

Some cities globally are moving to restrict access to polluting private vehicles through pricing mechanisms or other measures. In Beijing, half of the cars on the roads are restricted each day, and new licence plates for petrol and diesel cars have been reduced from 240,000 to 150,000. It is also easier to access the 20,000 plates for electric vehicles, thereby encouraging uptake.[107] In the UK, around 55% of car journeys are under 5 miles, meaning that many of these trips could be made by walking, cycling or by public transport. Making these methods of travel more attractive can encourage people to make the switch from private car use.[108]

In Stockholm, the successful introduction of congestion charging has led to large reductions in city traffic volumes and congestion as well as carbon emissions and air pollution. This reduction in traffic volumes has been achieved even though the population is growing by around 40,000 people a year. The revenue generated through the congestion charge is used to fund road improvement projects across Stockholm.

Initially alternative fuel vehicles were exempt from the tax, which led to an increase in purchase of hybrid and electric cars.[109] Although this exemption is no longer in place, the shift to alternative fuels has continued to gather pace.

IN STOCKHOLM, THE SUCCESSFUL INTRODUCTION OF CONGESTION CHARGING HAS LED TO LARGE REDUCTIONS IN CITY TRAFFIC VOLUMES AND CONGESTION AS WELL AS CARBON EMISSIONS AND AIR POLLUTION.

In Nottingham the city council has introduced a Work Place Parking Levy – a charge on employers who provide workplace parking. The scheme was introduced to tackle problems associated with traffic congestion by both providing funding for local transport and by acting as an incentive for employers to manage and potentially reduce their workplace parking. Money raised from the levy has gone towards and extension of the city's tram system, the redevelopment of the mainline railway station and improvements to the local bus network.[110]

IN NOTTINGHAM THE CITY COUNCIL HAS INTRODUCED A WORK PLACE PARKING LEVY – A CHARGE ON EMPLOYERS WHO PROVIDE WORKPLACE PARKING.

Constrained Funding

According to the International Transport Forum, it is clear that no single financing model is the answer to this investment challenge due to the great diversity of local situations and needs. It is also clear that models that work in large, dense cities may not work in smaller urban areas.[111]

The International Transport Forum[112] notes that national governments can play an important role in supporting public transport funding through measures such as:

- Giving high priority to urban public transport investment programmes

- Improving urban mobility through stronger institutional arrangements, including the empowerment of local government and more private sector participation

- Integrating public transport into land use planning and development policies

- Supporting innovation in technology and policy enabling new transport business models and improving efficiency

In light of restricted funding and spending, easy-to implement measures that provide a wider impact, such as investments in active travel, could be introduced much more rapidly and at relatively low cost.

Commuting by bicycle has increased in popularity over the past decade, with more dedicated cycle networks and cycle lanes being implemented.

The 2013 Spending Review showed that the coalition Government invested almost £700million in cycling through the Local Sustainable Transport Fund, Community Linking Places Fund and Cycle Safety Fund, in addition to allocations provided to local authorities. It also provides funding for extra cycle parking at stations and for cycle hire and repair facilities.

Local authorities are also dedicating investment to cycling. Birmingham's city council, for example, produced a sustainable cycling strategy to encourage more cycling in the city and made a commitment of £1 million for cycling facilities from 2011 to 2015.[113]

Cities also increasingly look for private sector involvement to bridge funding gaps. Approaches include the better integration of transport stations with civic or retail facilities.

IN THE LIGHT OF RESTRICTED PUBLIC FUNDING EASY AND QUICK TO IMPLEMENT MEASURES THAT HAVE HIGH IMPACTS OVER A WIDE AREA – SUCH AS ACTIVE TRAVEL – HAVE CONSIDERABLE ADVANTAGES.

People's use of stations is changing, from transit thoroughfares to becoming destinations in their own right. Stations could become lifestyle hubs with multiple amenities.

An example of private-sector involvement in financing transport infrastructure is a new-build rail station in Boston, funded by New Balance. The station was designed to serve the New Balance headquarters, while simultaneously serving the local community. Instead of waiting for the underfunded local government to construct a station, the company invested and paid for construction and ten years of service.[114]

Transport makes a major contribution to a host of wider sectoral goals. For example bus services can give the workless access to work, young people access to education and opportunity, provide access to healthcare and provide the links that new development sites need. There is enormous scope for cities to release savings and synergies by recognising the contribution that transport makes to these outcomes and planning and funding transport in a more coordinated way with planning for healthcare, economic development, social inclusion and education.

For example greater pooling of budgets and vehicle fleets across currently separate transportation provision for social services, education, healthcare and regular public transport could result in savings and efficiencies.

CASE STUDIES

Electric buses in Paris

French bus operator RATP has announced it will be transforming its 4,500 vehicle bus fleet to at least 80% battery electric by 2025. Trials of electric buses and recharging systems are underway to demonstrate how RATP plans to achieve a 100% zero-emission fleet in ten years. The first stage of the plan is to restrict all new bus purchases to hybrid, electric and gas technologies only. If successful the programme will reduce RATP's carbon footprint by 50%.

Hamburg Urban Greenway

The city of Hamburg is planning to implement an extensive 27 square-mile network of bike and pedestrian greenways by 2030. The green network will cover 40% of the city's land area and will provide access to the entire city without requiring users to interact with motor vehicle traffic. It will link green areas on the outskirts of the city with parks, recreational areas, gardens and other green spaces within the city.
It will also create a city that is more resilient to flooding and less reliant on motorised transport.

Singapore Vehicle Tax

In order to reduce congestion on the small island state, Singapore's government makes owning a vehicle extremely expensive. A car is taxed at least 100% of its open market value and owners are required to pay for a certificate of entitlement at an average cost of US $70,000. This system means that only about 15% of Singaporeans own a car.

Pasadena FoldNGo

Officials in Pasadena, California are offering people who live, work, or attend school in the city US$220 to help buy folding bikes in an attempt to bridge the last mile transport issue. Participants are expected to take public transport with their folding bikes at least twice a week. The programme provides a "triple bottom line" – providing benefits for the environment, for people's health, and for the finances of transit agencies.

Transit Oriented Development Arlington, USA

Thirty years ago, when the Rosslyn Ballston commercial corridor was in decline, local government decided to prioritise high-density, mixed-use development around five closely located rail stations. The results of this transit-oriented development include: In 10 years, the value of land around stations increased by 81%; the 8% of county land the corridor occupies generates 33% of county revenues; half of all residents use public transit to get to work; and 73% of residents walk to stations.

FORWARD THINKING CITIES WILL...

> Ensure that governance is focused on the right decisions being taken at the right level. Strong city leadership will facilitate more effective changes to urban transport systems.

> Look for new and innovative ways of funding and supporting transport systems including looking for opportunities for synergies and savings through breaking down barriers between policy areas to encourage more effective public spending.

> Consider the utilisation of demand management measures to reduce traffic congestion, improve the urban realm and raise funding for alternative transport provision.

> Think about the potential for stations and interchanges to be better linked to housing and development opportunities – as well as serving wider civic, local enterprise and community purposes.

> Focus investment and revenue support where it can achieve multiple aims in a timely and cost effective way. This will include getting the right balance between expensive and location specific infrastructure schemes which take time to implement, and measures that can have a wider impact more quickly – such as investments in active travel and other measures which can be introduced rapidly, over a wide area and at relatively low cost.

> Integrate public transport better into land-use planning and development policies, to ensure that the transport links the city need can be provided in efficient and sustainable way.

> Look to find new ways of engaging with citizens on how transport challenges are prioritised, planned and implemented through combining open data with a more open approach.

SCENARIOS AND FUTURE POLICY ACTIONS

	Negative Scenario	Positive Scenario	Policy actions
Citizens and Lifestyle	There is a housing crisis with inadequate and inappropriate housing provision and new developments are not built to good environmental standards.	Adequate and appropriate housing is provided for a diverse population, including an increase in single person households.	Prioritise the building of adequate housing.
	Obesity is a problem in the UK. Personal mobility is limited to private vehicles which don't encourage active lifestyles or lend themselves to the design of pleasant and walkable streets.	Good quality public space and infrastructure encourages people to walk or cycle, especially for short trips.	Introduce measures to encourage active travel, especially walking and cycling.
	The transport system does not cater well for an ageing society, with poor accessibility and little provision for the hearing or sight impaired.	Transport has been designed to be broadly accessible, including by older people. Different reasons for travelling and different types of trips are also accommodated.	Ensure transport systems are accessible to a wide range of users and caters to different and evolving needs.
	Population growth has put pressure on urban transport services and there has been a failure to build adequate capacity. Public transport is overcrowded and unpleasant, straining under the demand.	There is adequate capacity on public transport, which is safe and reliable, encouraging people to leave their cars at home, advanced videoconferencing, holographic software and flexible working reduces some trips made for work purposes.	Invest in transport infrastructure, especially public transport.

	Negative Scenario	Positive Scenario	Policy actions
Urban Environments	Cities are congested and overpopulated, putting pressure on services. Inadequate transport infrastructure makes it difficult for people to access jobs and leisure activities.	Places are well connected and accessible. Urban areas are pleasant and welcoming with a variety of good quality green and public spaces.	Enable multi-modal transport networks and good quality public space.
	Lack of good planning practices has resulted in few green spaces, and impermeable surfaces have worsened the effects of flooding.	Significant green infrastructure means that urban areas are attractive, environmentally sensitive and enhance quality of life.	Encourage green infrastructure and the protection of ecosystems.
	Movement of people and goods are prioritised over environmental protection. Increases in freight transport have led to worsening congestion and lower efficiency.	The environment is valued and protected. Alternative and more efficient logistics systems have resulted in decreased emissions.	Ensure long haul freight accesses cities by rail or water where possible and last mile deliveries are by low or zero carbon modes where possible.
	There has been an increase in the frequency of extreme weather events with severe consequences for transport infrastructure.	Global climate change mitigation and adaptation policies have limited the impacts of global warming.	Create ambitious air quality and emission reduction targets, and implement measures to reach these.

	Negative Scenario	Positive Scenario	Policy actions
Systems and Technology	A growing population and increased traffic and congestion has resulted in growing energy use and emissions. The majority of travel is by private vehicle, which offsets many of the gains from cleaner technologies.	Efficient energy technologies and micro-generation are widely used, and most vehicles are electrified to some extent, with power derived from renewable sources.	Provide incentives for ultra low emission vehicles.
	Fossil fuel use has decreased, but not to an extent significant enough to reduce emissions and pollution to agreed EU targets.	Connected, autonomous and electric vehicles provide a safer and greener means of private transport, and ITS has relieved congestion. Autonomous vehicles have enabled mobility for older people and those with mental and physical impairments.	Encourage the development and uptake of connected, autonomous and electric vehicles. Implement smart transport solutions.
	The Internet of Things and use of big data has been constrained by lack of open access. Where these are used, security and privacy concerns have not been adequately addressed.	The Internet of Things and big data has enabled more efficient transport systems, more reliable and comfortable journeys, and more sustainable urban centres.	Provide open access to relevant data and ensure the security and integrity of the data.
	Transport modes are not well integrated and companies tend to be wary of releasing their data to third parties.	Smart technology enables real-time information and integrated services, while smart ticketing enables interoperability.	Enable measures to ensure good connectivity between modes and easy interoperability across different systems.

	Negative Scenario	Positive Scenario	Policy actions
Cities and Policy	Lack of incentives to encourage greener transport technologies means that public transport is still a large contributor of emissions.	Public transport is safe and reliable and appropriately funded. Greener technologies have increased efficiency and decreased emissions.	Provide incentives for greener technologies.
	Transport, infrastructure and energy policies are ineffective in supporting the growing population and in implementing demand management measures.	Infrastructure is identified as an important area for investment, and effective partnerships between public and private bodies ensure good service provision. There is good integration of urban regeneration, transport planning and land use policies.	Aim to reduce demand on transport infrastructure. Integrate urban regeneration, transport planning and land use policies.

	Negative Scenario	Positive Scenario	Policy actions
Cities and Policy	National government controls most of the transport budgets and lacks understanding of local contexts. No single transport governance or authority is in place to coordinate multi-modal travel.	Bold and capable urban leadership has encouraged integrated, accessible and sustainable urban transport networks.	Encourage a strong leadership model for urban areas or city conurbations.
	There is a dependence on national government policies for climate change adaptation.	Locally devolved powers have helped to fund transport networks and have resulted in local climate change mitigation policies.	Devolve powers to local authorities especially in terms of transport and climate change adaptation.

REFERENCES

1. OECD International Futures Programme. The Future of Families to 2030: A Synthesis Report. 2011. Available from: http://www.oecd.org/sti/futures/49093502.pdf

2. Americans work too long (and too often strange times), by Daniel S. Hamermesh and Elena Stancanelli. 2014. Available from: http://www.voxeu.org/article/americans-work-long-and-strange-times

3. Working Time Around the World: Trends in working hours, laws and policies in a global comparative perspective, by Sangheon Lee, Deirdre McCann and Jon C. Messenger. 2007. Routledge. Available from: http://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_104895.pdf.

4. TfL 90993 – Impact of the Night Tube on London's Night-Time Economy. Volterra Partners. 2014. London. Available from: https://www.tfl.gov.uk/cdn/static/cms/documents/night-time-economy.pdf

5. Greater Manchester Transport Strategy 2040: Our Vision. Transport for Greater Manchester. 2015. Available from: http://www.tfgm.com/2040/Documents/14-1882%20GM%20Transport%20Vision%202040.pdf

6. Global Employment Trends 2014: Risk of a jobless recovery? International Labour Organization. 2014. Available from: http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_233953.pdf

7. The geography of youth unemployment: a route map for change. The Work Foundation. Lizzie Crowley and Nye Cominetti. 2014. Available from: http://www.theworkfoundation.com/DownloadPublication/Report/360_The%20Geography%20of%20Youth%20Unemployment%20FINAL%2008%2004%2014.pdf

8. Ticket to Thrive: The role of urban public transport in tackling unemployment. pteg. 2015. Available from: http://www.pteg.net/system/files/general-docs/PTEG%20%E2%80%93%20Ticket%20to%20Thrive%20Final%20Feb%2015.pdf

9. The end of monitoring. The Guardian. 2011. http://www.theguardian.com/politics/2011/sep/25/end-of-motoring

10. End of the car age: how cities are outgrowing the automobile. The Guardian. Stephen Moss. 2015. Available from: http://www.theguardian.com/cities/2015/apr/28/end-of-the-car-age-how-cities-outgrew-the-automobile

11. Closing Streets to Cars – for Good. Copenhagenize. 2013. Available from: http://www.copenhagenize.com/2013/03/closing-streets-to-cars-for-good.html

12. World Population Prospects: 2015 Revision. United Nations. 2015. Available from: http://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf

13. Zukunft der Mobilität: Szenarien für das Jahr 2030. Ifmo. 2010. Available from: http://www.ifmo.de/tl_files/publications_content/2010/ifmo_2010_Zukunft_der_Mobilitaet_Szenarien_2030_de.pdf

14. World Population Prospects: The 2012 Revision. United Nations. 2013. Available from: http://esa.un.org/wpp/documentation/pdf/wpp2012_%20key%20findings.pdf

15. Older driver involvements in police reported crashes and fatal crashes: trends and projections. S. Lyman, S. Ferguson, E. Braver and A. Williams. 2002. Injury Prevention 2002; 8: 116-120. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1730843/pdf/v008p00116.pdf

16. Impacts on Mobility and Transport. Compass. 2011. Available from: http://www.fp7-compass-keytrends.eu/index.php/66-impacts-on-mobility-and-transport2#The_social_domain

17. Seven Themes for the Coming Decade. World Future Society: The Futurist. 2012. Available from: http://www.wfs.org/blogs/james-lee/seven-themes-for-coming-decade

18. Sharing is the New Buying. Vision Critical. 2014. Available from: http://www.web-strategist.com/blog/2014/03/03/report-sharing-is-the-new-buying-winning-in-the-collaborative-economy/

19. The sharing economy – sizing the revenue opportunity. PwC. Available from: http://www.pwc.co.uk/issues/megatrends/collisions/sharingeconomy/the-sharing-economy-sizing-the-revenue-opportunity.jhtml

20. Have your say: the sharing economy debate. PwC. Available from: http://www.pwc.co.uk/issues/megatrends/collisions/sharingeconomy/have-your-say-the-sharing-economy-debate.jhtml

21. Carsharing: A Sustainable and Innovative Personal Transport Solution with Great Potential and Huge Opportunities. Frost & Sullivan. 2010. Available from: https://www.frost.com/sublib/display-market-insight.do?id=190795176

22. Improving the health of Londoners; Transport Action Plan. Transport for London, Mayor of London. 2014. London. Available from: https://www.tfl.gov.uk/cdn/static/cms/documents/improving-the-health-of-londoners-transport-action-plan.pdf

23. UK among worst in western Europe for level of overweight and obese people. The Guardian. 2014. Available from: http://www.theguardian.com/society/2014/may/29/uk-western-europe-obesity-study

24. Transport & Health: Briefing statement. Faculty of Public Health. Available from: http://www.fph.org.uk/uploads/briefing%20statement%20transport%20V2.pdf

25. Copenhageners love their bikes. Denmark: The Official Website of Denmark. Available from: http://denmark.dk/en/green-living/bicycle-culture/copenhageners-love-their-bikes/

26. Zurich plans to make walking the primary mobility mode (Switzerland). Eltis. 2014. Available from: http://www.eltis.org/discover/news/zurich-plans-make-walking-primary-mobility-mode-switzerland-0

27. Renting your way to poverty: welcome to the future of housing. The Telegraph. 2015. Available from: http://www.telegraph.co.uk/finance/property/11482696/Renting-your-way-to-poverty-welcome-to-the-future-of-housing.html

28. Record average rents hit £761 per month – or £1,160 in London. The Independent. 2014. Available from: http://www.independent.co.uk/money/spend-save/record-average-rents-hit-761-per-month--or-1160-in-london-9742491.html

29. Greater Manchester Transport Strategy 2040: Our Vision. Transport for Greater Manchester. 2015. Available from: http://www.tfgm.com/2040/Documents/14-1882%20GM%20Transport%20Vision%202040.pdf

30. Birmingham housing crisis needs supremo to sort out the mess, say Lib Dems. Birmingham Mail. Neil Elkes. 2013. Available from: http://www.birminghammail.co.uk/news/local-news/birmingham-housing-crisis-needs-supremo-4282844

31. Vital Cities not Garden Cities: the answer to the nation's housing shortage. Future Spaces Foundation. 2015. Available from: http://www.futurespacesfoundation.org/wp-content/uploads/2015/03/Vital-Cities-not-Garden-Cities-FSF.pdf

32. Rise of the 'super-commuter': Number of Britons travelling three hours each day for work soars by 50 per cent in five years. Mail Online. 2013. Available from: http://www.dailymail.co.uk/news/article-2325262/Rise-super-commuter-Number-Britons-travelling-hours-day-work-soars-50-cent-years.html

33. Living Planet Report 2012. WWF. 2012. Available from: http://awsassets.panda.org/downloads/1_lpr_2012_online_full_size_single_pages_final_120516.pdf

34. Updated energy and emissions projections 2014. Department of Energy & Climate Change. 2014. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/368021/Updated_energy_and_emissions_projections2014.pdf

35. OECD Environmental Outlook to 2050. OECD. 2012. Available from: http://www.keepeek.com/Digital-Asset-Management/oecd/environment/oecd-environmental-outlook-to-2050_9789264122246-en#page4

36. Global and European sea-level rise (CLIM 012) - Assessment published Jul 2014. European Environment Agency. 2014. Available from: http://www.eea.europa.eu/data-and-maps/indicators/sea-level-rise-3/assessment

37. Risk of Exposure of World's Cities to Natural Disasters. United Nations, Population Division. Available from: https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=ssource=web&cd=5cad=rja&uact=8&ved=0QFjAE&url=http%3A%2F%2Factivities.iussp.org%2Fcolloquedownload.php%3Ffilename%3D1788.pdf&ei=2_5xVqZClKM7Qa07IOwDA&usg=AFQjCNHW5QaHrTHDgGaix04GC-MumeLSA&sig2=jSE28O1fuexpeT1exTS3g

38. The great flood of London: Experts warn risk to Capital from rising sea levels 'worse than feared'. DailyMail. 2013. Available from: http://www.dailymail.co.uk/sciencetech/article-2324741/Risk-London-worse-feared-rising-sea-levels.html

39. Climate Change: Sea Level Rises. BBC Weather Centre. Available from: http://www.bbc.co.uk/climate/impact/sea_level.shtml

40. UK flood fund underestimates number of homes at risk. The Carbon Brief. 2013. Available from: http://www.carbonbrief.org/blog/2013/08/uk-flood-fund-underestimates-the-number-of-homes-at-risk/

41. Facing up to Rising Sea-Levels: Retreat? Defend? Attack? Building Futures RIBA, Institution of Civil Engineers. Available from: http://www.buildingfutures.org.uk/assets/downloads/Facing_Up_To_Rising_Sea_Levels.pdf

42. Sea Level Rise. Houses of Parliament. PostNote Number 363 September 2010. Available from: http://www.parliament.uk/documents/post/postpn363-sea-level-rise.pdf

43. Birmingham Urban Climate Laboratory: Monitoring Birmingham's Urban Heat Island. Duncan Wilson. 2013. Available from: http://www.iotschool.org/blog-bucl/

44. Mapping Manchester's urban heat island. Sylvia Knight, Claire Smith and Michael Roberts. Weather – July 2010, Vol. 65, No. 7. 2010. Available from: http://metlink.org/wp-content/uploads/2013/07/urban_heat_

45. Urban heat islands. Met Office. 2012. Available from: http://www.metoffice.gov.uk/media/pdf/8/m/MO_PUP_insert_HEALTH.web.pdf

46. Green infrastructure and the urban heat island. Forest Research: Evidence Note. Available from: http://www.forestry.gov.uk/pdf/urgp_evidence_note_004_Heat_amelioration.pdf/$FILE/urgp_evidence_note_004_Heat_amelioration.pdf

47. Humanity Can and Must Do More with Less: UNEP Report. 2011. Available from: http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=2641&ArticleID=8734

48. EU Transport GHG: Routes to 2050 II. Nicolas Hill, Charlotte Brannigan, Richard Smokers, Arno Schroten, Huib van Essen and Ian Skinner. 2012. Available from: http://www.eutransportghg2050.eu/cms/assets/Uploads/Reports/EU-Transport-GHG-2050-II-Final-Report-29Jul12.pdf

49. Towards low carbon transport in Europe. European Commission. 2012. Available from: http://www.transport-research.info/Upload/Documets/201204/20120423_214705_81522_PB02_web.pdf

50. Energy and emissions in the UK. Office for National Statistics. 2015. Available from: http://visual.ons.gov.uk/uk-perspectives-energy-and-emissions/

51. 2013 UK Greenhouse Gas Emissions, Final Figures. Department of Energy & Climate Change. 2015. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/407432/20150203_2013_Final_Emissions_statistics.pdf

52. Energy Use in Transport. Institution of Mechanical Engineers. Available from: http://www.imeche.org/knowledge/policy/energy/policy/energy-use-in-transport

53. Updated energy and emissions projections 2014. Department of Energy & Climate Change. 2014. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/368021/Updated_energy_and_emissions_projections2014.pdf

54. World Population Prospects: The 2012 Revision. 2013. Available from: http://esa.un.org/wpp/documentation/pdf/wpp2012_%20key%20findings.pdf

55. Urban population growth. World Health Organisation. 2014. Available from: http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/

56. World Urbanization Prospects [highlights]. United Nations. 2014. Available from: http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

57. Transport Outlook: Meeting the Needs of 9 Billion People. International Transport Forum. 2011. Available from: http://www.internationaltransportforum.org/Pub/pdf/11Outlook.pdf

58. Two Billion Cars: Driving Toward Sustainability. Sperling and Gordon. 2009. Oxford University Press.

59. Planning and Design for Sustainable Urban Mobility: Global Report on Human Settlements. UN Habitat. 2013. Earthscan.

60. Pension Funds Investment in Infrastructure Survey. OECD. 2011. Available from: http://www.oecd.org/futures/infrastructureto2030/48634596.pdf

61. Keeping Britain moving: The United Kingdom's transport infrastructure needs. McKinsey&Company. 2011. Available from: http://www.mckinsey.com/global_locations/europe_and_middleeast/united_kingdom/en/latest_thinking/keeping_britain_moving_full

62. 50% Rise in Gridlock Costs by 2030. Centre for Economic and Business Research. 2014. Available from: http://www.cebr.com/reports/the-future-economic-and-environmental-costs-of-gridlock/

63. Counting the Future Cost of Gridlock. CEBR, INRIX. 2014. Available from: http://www.inrix.com/wp-content/uploads/2014/10/INRIX_CEBR_GLOBAL_INFOGRAPHIC_FINAL_FINAL-HI-RES4.jpg

64. Keeping Britain moving: The United Kingdom's transport infrastructure needs. McKinsey&Company. 2011. Available from: http://www.mckinsey.com/global_locations/europe_and_middleeast/united_kingdom/en/latest_thinking/keeping_britain_moving_full

65. Traffic congestion on roads costs UK economy £4.3bn a year. Roadtraffic-technology. 2012. Available from: http://www.roadtraffic-technology.com/news/newstraffic-congestion-roads-costs-uk-economy-43bn

66. Urban Air Pollution: United Nations Environment Programme. Available from: http://www.unep.org/urban_environment/issues/urban_air.asp

67. Air quality deteriorating in many of the world's cities. World Health Organization. 2014. Available from: http://www.who.int/mediacentre/news/releases/2014/air-quality/en/

68. European Commission. Low Emission Zones - Why LEZs? – Health! 2014; Available from: http://urbanaccessregulations.eu/low-emission-zones-main/why-lezs-health

69. Hamburg Announces Plans to Become a Car-Free City Within 20 Years. Inhabitat. 2014. Available from: http://inhabitat.com/hamburg-announces-plans-to-become-a-car-free-city-within-20-years/

70. The Future of Rail. Arup. 2014. Available from: http://arup.com/for

71. AW Megatrends. Automotive Megatrends Magazine | Q2 2014. 2014. Available from: http://issuu.com/megatrends/docs/automotive_megatrends_magazine_q2_2/33?e=12633881/8543321

72. Big data universe beginning to explode. CSC. 2012. Available from: http://www.csc.com/insights/flxwd/78931-big_data_universe_beginning_to_explode

73. The death of the featurephone in the UK – and what's next. Arthur, C. 2014. The Guardian. Available from: http://www.theguardian.com/technology/2014/apr/30/featurephone-smartphone-uk-

74. £73 million to improve access to data and drive innovation. Department for Business, Innovation and Skills. 2014. Available from: https://www.gov.uk/government/news/73-million-to-improve-access-to-data-and-drive-innovation

75. Urban Mobility In The Smart City Age. Arup, Schneider Electric and The Climate Group. 2014. Available from: http://digital.arup.com/wp-content/uploads/2014/06/Urban-Mobility.pdf

76. Sao Paulo city government trials Big Data to improve public transport. Thinking Highways. 2015. Available from: http://thinkinghighways.com/sao-paulo-city-government-trials-big-data-to-improve-public-transport/

77. Smart city spending to reach $ 20 billion by 2020. GreenBiz. 2013. Available from: http://www.greenbiz.com/news/2013/03/06/growth-smart-cities

78. Internet Security Threat Report 2014. Symantec. 2014. Available from: http://www.symantec.com/security_response/publications/threatreport.jsp

79. Could Your Security Vulnerabilities Cause Network Gridlock? A Discussion Paper for Transportation Information Technology Leaders and Executive. CGI. 2013. Available from: http://www.cgi.com/sites/default/files/white-papers/transportation-information-technology_security-vulnerabilities-causing-network-gridlock.pdf

80. Powertrains Drive the Future of Engine Design. Crawford, M. 2013. ASME. Available from: https://www.asme.org/engineering-topics/articles/transportation/powertrains-drive-future-engine-design

81. If Tesla's Gigafactory can run on 100% renewable energy, why can't others? Mearian, L. 2014. ComputerWorld. Available from: http://www.computerworld.com/article/2604352/if-tesla-s-gigafactory-can-run-on-100-renewable-energy-whycan-t-others.html

82. TESLA Motors. Website. Available from: http://www.teslamotors.com/findus#/bounds/49.38,-66.94,25.82,-124.39,d?search=supercharger&name=us

83. Folding cars offer solution to urban transport problems. BBC future. Steven Ashley. 2012. Available from: http://www.bbc.com/future/story/20120613-folding-cars-offer-city-solution

84. Smart Grid Projects Outlook 2014. European Commission. Catalin Felix Covrig, Mircea Ardelean, Julija Vasiljevska, Anna Mengolini, Gianluca Fulli, Eleftherios Amoiralis. 2014. Available from: http://ses.jrc.ec.europa.eu/sites/ses.jrc.ec.europa.eu/files/u24/2014/report/ld-na-26609-en-n_smart_grid_projects_outlook_2014_-_online.pdf

85. Smart Grids and Electric Vehicles: Made for Each Other? Discussion Paper No. 2012-02. International Transport Forum. Trevor Morgan. 2012. Available from: http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DP201202.pdf

86. The Next Generation of the Internet Revolutionizing the Way We Work, Live, Play, and Learn. Cisco Internet Business Solutions Group. 2013. Available from: http://www.academia.edu/5177045/Cisco_Internet_Business_Solutions_Group_IBSG

87. Transforming Infrastructure. Cambridge Centre for Smart Infrastructure and Construction, Annual Review 2014. University of Cambridge. 2014. Available from: http://www-smartinfrastructure.eng.cam.ac.uk/files/CSIC_Annual_Review2014smlr.pdf

88. The road to 2020 and beyond: What's driving the global automotive industry? McKinsey & Company. 2013. Available from: http://www.mckinsey.com/Search.aspx?q=the%20road%20to%202020&l=Insights%20%26%20Publications

89. Comparative urban governance. Foresight, Government Office for Science. 2014. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/360420/14-810-urban-governance.pdf

90. Future of Highways. Arup. 2014. Available from: http://www.arup.com/foh

91. Driverless car review launched by UK government. Wakefield, J. 2015. BBC news online. Available from: http://www.bbc.co.uk/news/technology-31364441

92. Autonomous Vehicles – Handing Over Control: Opportunities and Risks for Insurance. Lloyd's. 2014. Available from: https://www.lloyds.com/~/media/lloyds/reports/emerging%20risk%20reports/autonomous%20vehicles%20final.pdf

93. Top misconceptions of autonomous cars and self-driving vehicles. Driverless car market watch. Available from: http://www.driverless-future.com/?page_id=774

94. Delivering the future: New approaches to urban freight. pteg. 2015. Available from: http://www.pteg.net/system/files/general-docs/Delivering%20the%20future%20FINAL%20020315.pdf

95. Delivering the future: New approaches to urban freight. pteg. 2015. Available from: http://www.pteg.net/system/files/general-docs/Delivering%20the%20future%20FINAL%20020315.pdf

96. Proposal to manage the demand for travel. Mayor's Transport Strategy. 2010. Greater London Authority, Mayor of London. Available from: https://www.london.gov.uk/sites/default/files/MTS_Chapter_5_pt6_0.pdf

97. Regent Street delivery and servicing reduction scheme. Arup. Available from: http://www.arup.com/Projects/Regent_Street_delivery_and_servicing_reduction_scheme.aspx

98. Unmanned Aerial Vehicles in Logistics: A DHL perspective on implications and use cases for the logistics industry. DHL Trend Research. 2014. Available from: http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_trend_report_uav.pdf

99. Sao Paulo city government trials Big Data to improve public transport. Thinking Highways. 2015. Available from: http://thinkinghighways.com/sao-paulo-city-government-trials-big-data-to-improve-public-transport/

100. Local Authority Intelligent Systems: The Its (UK) Deployment, Business Cases and Funding. ITS UK. 2014. Available from: http://www.its-uk.org.uk/filelibrary/file/Local_Authority_ITS_Guide_2014edition.pdf

101. Making Transport Local: Devolution of Transport in England Outside London. Campaign for Better Transport. 2014. Available from: http://www.bettertransport.org.uk/sites/default/files/research-files/14.10.making-transport-local.pdf

102. Devolution of Transport Powers – Opportunities for the UK. Transport Planning Society. 2015. Available from: http://www.tps.org.uk/main/events/id/0754

103. Greater Manchester Transport Strategy 2040: Our Vision. Transport for Greater Manchester. 2015. Available from: http://www.tfgm.com/2040/Documents/14-1882%20GM%20Transport%20Vision%202040.pdf

104. Bogota: More bikes and buses, fewer cars. DAC & Cities. Available from: http://www.dac.dk/en/dac-cities/sustainable-cities/all-cases/transport/bogota-more-bikes-and-buses-fewer-cars/

105. Comparative urban governance. Foresight, Government Office for Science. 2014. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/360420/14-810-urban-governance.pdf

106. Lessons in Travel Demand Management from the London Olympics. Trapeze Group. 2014. Available from: http://www.trapezegroup.co.uk/blog/article/lessons-in-travel-demand-management-from-the-london-olympics#sthash.T4MaPs0S.dpuf

107. Beijing Slashes Car Sales Quota By 40 Percent To Tackle Air Pollution. Green Car Reports. 2013. Available from: http://www.greencarreports.com/news/1088194_beijing-slashes-car-sales-quota-by-40-percent-to-tackle-air-pollution

108. Policy paper 2010 to 2015 government policy: local transport. Department for Transport. 2012. Available from: https://www.gov.uk/government/publications/2010-to-2015-government-policy-local-transport/2010-to-2015-government-policy-local-transport

109. Stockholm Green Economy Leader Report. LSE Cities. 2013. Available from: http://files.lsecities.net/files/2013/06/LSE-2013-Stockholm-Final-Report-webhighres.pdf

110. About the Workplace Parking Levy (WPL). Available from: http://www.nottinghamcity.gov.uk/whatisaWPL

111. Funding Urban Public Transport. Case Study Compendium. International Transport Forum. 2013. Available from: http://www.internationaltransportforum.org/pub/pdf/13Compendium.pdf

112. Bike Birmingham: A sustainable city;s cycling strategy 2011-2015. Birmingham City Council. 2011. Available from: http://www.birmingham.gov.uk/cycling/strategy

113. New Balance Sidesteps Boston Government, Builds Its Own Train Station. Racked.com. Adele Chapin. 2015. Available from: http://www.racked.com/2015/5/12/8594187/new-balance-boston-train-station

114. London gets 24 times as much spent on infrastructure per resident than north-east England. The Guardian. George Arnett. 2014. Available from: http://www.theguardian.com/news/datablog/2014/aug/07/london-gets-24-times-as-much-infrastructure-north-east-england