

# Rethinking Urban Mobility

Three questions that will shape the future  
of transport in cities



THALES



ARUP

Published as part of the London Transport Museum Interchange programme

## **London Transport Museum**

No other capital city is defined and shaped so much by its transport as London.

London Transport Museum is a window into the past, present and future of how transport keeps London moving, working and growing, and makes life in our city better. Interchange, a thought leadership programme facilitated by the Museum, builds on our role as a platform for debate and creativity for the wider transport industry. It is a programme of thought-provoking and informed discussions and debates for leading thinkers and decision-makers to consider the challenges and opportunities facing cities, transport and infrastructure, today and tomorrow.

## **Arup**

Arup is an independent consultancy providing professional services in management, planning, design and engineering. As a global firm we draw on the skills and expertise of nearly 13,000 consultants across a wide range of disciplines. Transport is one of Arup's four strategic markets. We aim to be at the forefront of changes in the transport market and deliver technologically innovative, resource-sensitive solutions through a fully integrated approach.

## **Gowling WLG**

Gowling WLG is an international law firm with more than 1,400 legal professionals in 19 cities worldwide. We provide our clients with in-depth expertise in key global sectors and a suite of legal services at home and abroad. We see the world through our clients' eyes, and collaborate across countries, offices, service areas and sectors to help them succeed, no matter how challenging the circumstances.

## **Thales**

In ground transportation, countries, cities and transport operators rely on Thales to help them adapt to rapid urbanisation and change in the way people travel – locally, between cities and across continents. Our expertise in Signalling, Communications and Security gives people and goods the connected journey they deserve to move safely and efficiently. A long-term partner operating in more than 50 countries, Thales draws on proven innovative approaches and experience to solve complex challenges for its customers. Whatever it takes.

Released February 2018

Published as part of the London Transport Museum Interchange programme

# ARUP

13 Fitzroy Street  
London W1T 4BQ  
[arup.com](http://arup.com)  
[driversofchange.com](http://driversofchange.com)  
© Arup 2018

© Arup

## **Contents**

Foreword	5
Introduction	6
Transport timeline: origins of modern transport and future scenarios	8
1 What role should cities play in shaping change?	11
2 How will demand-responsive transport impact urban systems?	21
3 Do the economic fundamentals of urban transport systems still add up?	31
4 Recommendations for cities	40
Urban mobility in future cities	44
Abbreviations and definitions	46
References	46
Participants and contributors	47
Acknowledgements	51



## Foreword



**Sam Mullins**  
Director  
London Transport Museum

There is no better place than London Transport Museum to see how the recent history of London, like the United Kingdom's other cities, has been shaped by step changes in technology: the arrival of the steam engine and the underground railway in the nineteenth century; the internal combustion engine at the start of the twentieth. At the beginning of the twenty-first century we are witnessing another rapid technological revolution, with communication-based technologies enabling radically different approaches to mobility for both people and goods.

There are lessons to be applied from the past, opportunities to be grasped, and questions to be answered to ensure that this revolution is harnessed to the best advantage of cities' inhabitants, present and future.

There are a number of challenges for city leaders, transport, technology and built environment professionals, as well as lawmakers and citizens whose opinions, choices and democratic rights will determine what kind of future is created.

For example, traditional public transport models are becoming very expensive to provide and they lack the flexibility that is increasingly being demanded by users. As such, public transport will face increasing competition from private mobility companies

that are placing a growing focus on seamless integration and user experience.

Nevertheless, transport must remain viable for different user groups, whether rush hour commuters, older people, night workers or tourists. The social good of transport may still need to be protected and regulated. Ultimately, the public sector should be creating the right frameworks in which to work with the private sector to deliver efficient services. To be adaptable and resilient in the future, cities will need bold and capable leadership.

In the debates that have given rise to this report we explored a range of issues and heard a wide variety of opinions on some key questions. The aim of this report is to reflect on these conversations and present some of the different views that emerged. The idea is not to give answers, but to make the debate more transparent and increase the speed of progress.

Please read it, share it, like it, dislike it, comment on it and get involved.

Ultimately, our hope is that public and private entities can work together to enable transformational change, and create urban mobility systems that enhance the quality of life of city residents.

## Introduction

Cities are hotbeds of innovation, and yet the fundamentals of our transport systems have not changed much over the last 50 years. However, in an environment of accelerating change and rapid technological advances, the urban mobility landscape must shift or even radically transform. Driven by population growth, consumer expectations, fiscal constraints, and environmental and health concerns, the mobility ecosystem is in a state of flux. Combined with the effects of disruptive technologies, these changes are giving rise to an exciting set of opportunities as well as complex challenges.

It is therefore a pressing time to consider the change that is occurring and understand the problems we are trying to solve. We need to think about how to shape our urban mobility systems today, as what we do now will impact our cities for decades and centuries to come.

In recognition of the need to proactively manage change in the UK, London Transport Museum, in collaboration with Arup, Gowling WLG and Thales UK, held a series of thought-provoking discussions for leading thinkers and decision-makers to consider the challenges and opportunities facing our cities' transport systems and infrastructure.

Three roundtable discussions were held to consider how to achieve transformational mobility change in UK cities. The discussion focused on topics including changing user demands and expectations, autonomous and intelligent technologies, and the strategies and policies required to achieve change.

**“Disruption is not necessarily negative. Over time it can become positive if we think about what it can do for the city.”**

**-Richard de Cani, Arup**

### UK landscape at a glance<sup>1</sup>

**32%**

share of UK CO<sub>2</sub> emissions resulting from transport.

**20M**

number of UK adults classified as physically inactive, costing the NHS £1.2bn per year.

**80%**

proportion of journeys into central London by rail and Underground.

**£250M**

amount earmarked by the UK Government to position the country as a global leader in Connected and Autonomous Vehicles.

A number of cross-cutting themes were then explored further in a workshop to better understand the trends and key uncertainties driving the shifts in the mobility landscape.

The outcomes of these discussions form the basis of this report. It is not a review of prior research or a comprehensive analysis of the mobility landscape, but rather a reflection of some of the key factors driving change as well as the challenges cities face in responding to them.

This report poses three major questions in order to start a conversation and to reflect on the collective views of the participants who were not always in agreement. It reflects the uncertainty of the times, and acknowledges that disruptive change will bring challenges but also opportunities for positive transformation.

To capitalise on these opportunities, there will need to be coordinated action between the private and public sectors. This will enable innovation and progress, while maintaining equity, inclusiveness and the safety of citizens.

**£307bn**

total cumulative cost of congestion in the UK from 2013 to 2030.

**62%**

proportion of trips in England made by car, accounting for 78% of distance travelled.

**2040**

the year by which the UK Government plans to ban the sale of new petrol and diesel cars.

**£500M**

investment by the UK Government to encourage uptake of electric vehicles.

# Transport timeline: origins of modern transport and future scenarios

											
<b>1829</b> First horse drawn bus service in London from Paddington to Bank.	<b>1830</b> Liverpool and Manchester Railway opens. It is the first public transport system without animal traction and becomes the template for all subsequent railways.	<b>1836</b> First passenger carrying railway in London from Deptford to Bermondsey.	<b>1863</b> World's first underground railway, the Metropolitan, opens from Paddington to Farringdon and is powered by steam.	<b>1883</b> Karl Benz invents the first car powered by an internal combustion engine.	<b>1908</b> Henry Ford develops the assembly line manufacturing process with the introduction of the Ford Model T.	<b>1935</b> Bus stops widely introduced in London. Previously, buses could stop on demand.	<b>1968</b> First automatic railway, the Victoria line, opens to the public. It features computer-controlled trains and automatic ticket barriers.	<b>1984</b> Birmingham International Airport runs the world's first commercial Maglev system.	<b>2003</b> Oyster card launches and Congestion Charge introduced for certain roads in central London.	<b>2010</b> Ultra PRT, the first modern commercial Personal Rapid Transit system starts operating at Heathrow Airport.	<b>2012</b> Elon Musk launches the concept for a "fifth mode of transport", calling it the Hyperloop.
											
<b>2016</b> Amazon completes first successful delivery by drone.	<b>2017</b> Dubai's flying taxi drone takes its first public flight in a test without a passenger.	<b>2021</b> First autonomous passenger drone service is launched in Dubai.	<b>2022</b> First fleets of self-driving cars, operating as a ride-sharing service, launch in Milton Keynes.	<b>2025</b> AVs are authorised to operate in bus lanes throughout Bristol.		<b>2026</b> First phase of High Speed 2 opens between London and Birmingham.	<b>2028</b> Carmakers agree on a standard design for electric AV charging points.	<b>2029</b> First Hyperloop carrying passengers is trialled in Denver, US.	<b>2037</b> Hyperloop opens between London and Edinburgh with a journey time of 50 minutes.	<b>2040</b> 95% of new vehicles sold in the UK are fully autonomous.	

# 1

## What role should cities play in shaping change?



“Heavy handed policy could choke innovation. We are now in an R&D environment so we don’t need it ... yet.”

—Mike Waters, Transport for West Midlands

### Discussion summary

While many cities in the UK are dependent on central government funding sources, power over transport policy is increasingly being devolved to the regional and city levels. It is therefore cities, rather than national governments, that will lead change and innovation in our transport systems. Metro mayors, who are often among the most dynamic and least ‘party’ political of elected representatives, have shown a willingness to become energetically engaged in transport issues. With their own budgets and responsibilities, city authorities will have more freedom to determine who operates in their cities and under what terms.

However, as the recent tensions between new service providers — such as Uber or bike sharing company oBike — and cities have shown, the relationship between innovation and regulation is not always an easy one.

There is a question whether the evolution of our mobility systems should be led by the market or by policy and regulation. Cities must manage this balance to enable change at the same time as influencing operators within their region. There are many related issues, including how to regulate without restricting innovation and competition, how to prevent a regulatory framework that protects vested interests rather than the user, and the role of taxation in directing innovation and its uptake. The role of the city will be to maximise opportunities to improve outcomes and align with priorities, whilst guarding against unintended consequences.

The separation between public and private transport will become less clear as we move towards an integrated service economy. For example, first and last mile partnerships between ride-sharing services and mass

**“** *The leaders will be cities rather than national governments. They are able to move faster, and transport is often high on mayoral agendas. If we need to regulate, it has to be at the correct time. There is a massive opportunity to do this right.”*

**—Richard Bruce, Department for Transport**



transit operators could create more seamless journeys. Key to this will be how data is shared to enable real-time information, unlock new services and create more efficient infrastructure and services.

As the blurring of public and private transport gathers pace, questions around the issue of social or public good and who the guardian should be will become more pressing and politically charged. The profit motive of private companies to provide public transport could be an issue, for example if their focus is only on the most profitable routes. This could undermine the economic sustainability of public transport systems.

It is suggested that low-income households are more likely to rely on public transport and are also disproportionately impacted by the negative externalities of transport, such as air pollution. Therefore, affordable and sustainable public transport is vital for social and economic mobility. Public and private entities will need to find ways of working together to ensure that transport stays competitive, whilst ensuring equity, privacy and safety. The objectives of cities (such as reducing environmental impact, increasing safety and supporting economic growth), as well as the objectives of commercial organisations and consumers need to be simultaneously maintained.

Recognising the differences between cities, their populations, and their specific mobility cultures is important. What has worked for London, for example, will not necessarily work for other cities. Given changes in demand and preferences, city-specific innovation and financing models will be a key factor for success.

## Evidence and related trends



### Policy leadership

In order to improve resilience and efficiency in the face of global issues such as climate change, city authorities need to take a lead and consider the interdependence of urban systems. Mayoral leadership increases visibility, legitimacy and decision-making power across a wide range of policy areas.

For example, the Mayor of London's Transport Strategy sets out policies and proposals to reshape transport in London over the next 25 years. Mayors have a good 'bird's eye view' to determine the competing demands of different systems such as transport, housing, policing and health. So far only 16 of the 326 local authorities in England have directly elected mayors, while the rest are still traditionally governed by a council leader elected by their fellow councillors.



### Health and environment

Concerns about health and the environment are driving change, and cities have an important role to play in nudging behaviours. Transport is responsible for around 32% of the UK's CO<sub>2</sub> emissions. Transport is also the biggest source of air and noise pollution in the UK and traffic noise negatively impacts many towns and cities. As a result, cities are focusing more on the role of the public realm in enabling activity, such as walking and cycling, as well as social connectedness and improving health and wellbeing.



## Land-use patterns

The UK population will continue to grow, especially in urban areas. As density increases, natural areas such as farmland will be transformed. This will have significant consequences for natural resources, biodiversity and climate change. Strategic urban and transport planning can mitigate these impacts and foster sustainable economic development and environments.

There is a trend towards more proactive land use planning, rather than land being used as a responsive mechanism. As the physical fabric of cities remains the same, the management of the space is of increasing importance.



## Security

Terrorism and cybersecurity breaches are fundamental threats to cities, with critical infrastructure particularly vulnerable. Since the London 7/7 bombings in 2005, a further 40 terror plots have been prevented, yet the risk remains high especially around public transport. The threat of remote hacking, already evident against key infrastructure, may expand to AVs and other smart transport systems. There are also reputational risks for cities, companies and industries if transport is not perceived as safe. The challenge for cities will be to create safe mobility access for everyone, including cyclists, older people, and those with disabilities.



## New technologies and business models

New technologies, connectivity and data mining are leading to new business models, such as Mobility as a Service and the sharing economy, which will have a big impact on cities. Opening up data assets enables the development of analytics and software for travel information and services. For example, travel apps use open source information to facilitate multi-modal journey planning. However, for technology such as AVs to flourish significant investment in connectivity will be required. Currently, less than 20% of UK roads have full 4G coverage and less than half have full 3G coverage.<sup>2</sup>



## Consumer opinion

Cities will need to influence consumer choices for the best possible policy outcomes. In the UK, public attitudes have changed and led to the increased popularity of public transport and alternative travel modes. A strong willingness of the British public to walk rather than travel by car for journeys shorter than two miles has increased from 6% in 2006 to 14% in 2016.<sup>3</sup> On the other hand, perceptions of public transport can be impacted by strikes, signal failures, weather delays and other issues. In the future, trust in AVs and attitudes towards shared vehicles will be important considerations.

## Key uncertainties and workshop reflections



Brexit

The full cost and changes to funding associated with Brexit remain uncertain. After Brexit, the development of a collaborative regulatory approach will be increasingly important to ensure all transport systems work together.



Rate of innovation

The speed of innovation means that there is a risk of obsolescence with the new quickly turning old. Consumer acceptance of technology may impact the speed of transition to new mobility services.



Climate change

Although there is widespread acceptance of climate change, the speed and scale of impacts on transport infrastructure remain uncertain. The UK is set to get warmer and wetter, and some cities will be impacted by rising sea levels. The benefits of new drivetrains, such as EVs, on climate change mitigation are also uncertain.



Energy security

The availability of alternative fuels, and cheaper methods of hydrocarbon extraction, could reduce the cost of transport and fundamentally change transport economics. New technologies and diverse energy sources could lead to greater energy security.



Transition

The transition to new modes of transport, like AVs, is highly uncertain and is likely to be complex. Cities will need to plan for these and coordinate the different companies providing services in their regions.



Demand

Although travel demand has increased steadily, it may not continue to increase in the future. For example, demand for rail, tube and bus declined in London during 2017.<sup>4</sup>

## Vision – what good looks like

**“ The role of the transport authority is not about provision, but about moderating the market.”**

–Simon Craven, Go-Ahead Group

Successful cities are home to healthy, happy and productive citizens, as well as attractive to visitors and businesses. To enable this, city authorities will need to provide mobility choices that are affordable but also work to reduce pollution, tackle congestion, increase safety, encourage physical activity and improve land use.

To succeed, city authorities will invest in a public realm that supports and encourages active transport, such as walking and cycling. A walkable city relieves pressure on public transit, as well as improving health and wellbeing. A critical mass of high-quality cycling infrastructure, from segregated cycle lanes to bike-share

schemes, reduces motorised traffic and harmful emissions. A targeted reduction in private car trips and ownership will improve local air quality and, more broadly, investment in electric vehicle charging points will help to tackle climate change. In planning transport provision, a successful city will provide safe mobility access for everyone, including children, older people and those with disabilities. New modes of transport will reduce inequality and promote inclusion, but only if their power to do so is recognised and encouraged.



**“**The prospect of ‘shared’ is what drives Uber. If we all own autonomous vehicles then AV tech has failed to reduce congestion and parking. The concept of individual car ownership has to go.”

**-Kieran Harte, Uber**

**“**Regulation will never be dynamic enough to predict the market failures of tomorrow. Proactively regulating to promote innovation, rather than creating a flexible and agile regulatory environment, is a contradiction.”

**-Sofia Taborda, Urban Mobility Consultant**

Successful cities will pursue open data policies. This will encourage private sector innovation and ultimately benefit transport users, whether via route-planning apps or driverless shuttles. Shared mobility or demand-responsive transport (DRT) will work best when complementing rather than cannibalising conventional mass transit. This can only be achieved with a progressive approach to data and partnerships. Improved coordination will allow data to flow between different systems, supporting seamless travel for users and holistic analysis by transport authorities.

New business models will blur the lines between public and private transport. Successful city authorities will balance income, long-term investment and user satisfaction with novel public-private partnerships. In tandem, the private sector will move towards Mobility as a Service (MaaS) provision that avoids replication and waste.

Better consumer choices will underpin a transport system that is more efficient and more environmentally sustainable. These informed decisions will come about by building consumer trust and through education; crucially, successful cities will enable viable and attractive alternatives to more polluting or inefficient options. With cleaner air, journeys on foot or by bike will become more attractive.

In any successful scenario, new opportunities and challenges will be met with policies that are fit for purpose and with effective leadership. Mayors and local authority leaders have oversight of multiple, inter-related and competing urban functions, including housing, policing and transport. A good outcome will see policy frameworks that are integrated across these functions, are consistent and transparent, and which set a firm direction for mobility in a city. This will leverage private sector innovation, speed up decision-making and lead to happier transport users.

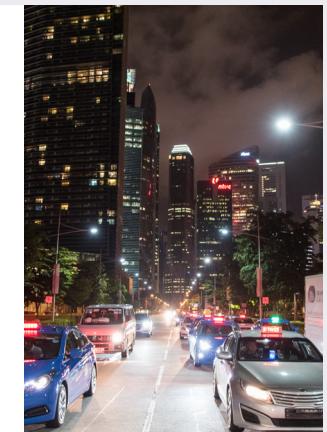


#### CASE STUDY

### Subsidised ride sharing pilot

**Centennial, Colorado**

The City of Centennial worked with Lyft and Go Colorado to offer residents free journeys to and from a local light rail station, encouraging mass transit use and decreasing reliance on cars. Ridership from the small catchment area grew steadily over the trial period, with each journey costing an average of US\$4.97. By integrating public mass transit and private ride-sharing options, schemes like this could extend and improve public transport networks at a fraction of the cost of conventional modes.



#### CASE STUDY

### Car ownership quotas

**Singapore**

Singapore has set its new vehicle growth rate at 0%, effectively capping the number of private vehicles allowed on the city's streets. It is hoped this will decrease reliance on travel by car, reduce car ownership over time, and free-up land. As car use decreases, land can be used for other purposes including leisure and housing. The policy sits alongside a US\$21 billion investment in rail and bus systems over the next five years, and a commitment to developing shared and autonomous vehicles.



#### CASE STUDY

### Shared ride-to-work service

**Bristol, UK**

Developed by international transport operator RATP Dev, Slide Bristol is a shared ride-to-work service which launched in 2016. An app enables users to book a ride to work, either in advance or minutes before travelling, without any location or timetable constraints. Pickup and drop off points are within a five minute walk of customers' homes and places of work. The service runs during peak commuting hours, and fares are fixed and upfront.



# 2

## How will demand-responsive transport impact urban systems?

“Technology lets us use our existing infrastructure more efficiently.”

—Philo Daniel, Thales

### Discussion summary

Demand-responsive transport (DRT) has the potential to disrupt transport systems, especially in cities, by personalising services and providing flexible routing. New technology companies, including Citymapper and Uber, have sophisticated methods to model demand, which could be used to help tackle transport challenges. In turn, the development of new tools or city partnerships could lead to better use of existing transport services and a reduction in car ownership.

It is difficult to know how people will want to travel in the decades to come, but there are some user requirements that appear to be foreseeable: people will live in one place and work in another, fewer people will own cars and cities will remain critical places of human interaction. Indeed it could be argued that user demand changes slowly, as the supply of conventional transport is mainly fixed.

However, more DRT could lead to significant changes in how people use the system, as it has the potential to match supply and demand with greater efficiency. This flexible approach should facilitate more seamless journeys and remove pinch points in the network. However, given that mass transport will always be most attractive in densely populated areas, DRT may affect just a small percentage of journeys. Therefore, DRT may help to improve the existing system, rather than create a major step change to city travel. It may offer greater opportunity in less densely populated cities, or in those dominated by car use.

DRT is a growing market and, as technology brings down barriers to entry, commercial operators are moving into the space. So how should transport operators engage with ride-sharing and demand-responsive services?

**“** Technology will play a role but, first and foremost, it's about taking people back to using their feet. The big challenges lie in infrastructure not the digital space.”

**-Ben Rogers, Centre for London**

**“** If the end-to-end journey is going to happen, the transport provider needs to think end-to-end.”

**-Abhishek Sen, NumberEight**

Do they continue to manage ‘point-to-point’ routes or be responsible for a user’s whole journey, from door-to-door? The latter could see operators working with ride-sharing and demand-responsive services, such as Uber or Lyft, or they could expand to compete with these services.

Rapid technological innovation could disrupt the market if not managed correctly. Uncertainty around the stability and longevity of emerging passenger and freight solutions will create risk for short-term partnerships between developers and regulators.



## Evidence and related trends



### Digital lifestyles

Mobile devices are increasingly at the centre of our digital lifestyles, delivering a vast range of informational services in support of our daily lives. The number of smartphone users in Britain is forecast to reach 44.9 million in 2018, representing a two-fold increase since 2011.<sup>5</sup> These devices, alongside open data and smart infrastructure will enable connected, more personalised journeys. Users can hail a ride, rent bikes and get real-time information about delays and availability.



### Seamless mobility

Intelligent transport systems and technologies allow transport modes to communicate with each other and with the wider environment, paving the way for truly integrated transport solutions and experiences. Journey planners already facilitate multi-modal journey selection, incorporating walking and cycling options. Interoperable ticketing and new payment systems also encourage multi-modal travel by providing a more fluid and convenient connection to other modes, alleviating pinch points. This will drive a shift away from private vehicles and car ownership. The emergence of Mobility as a Service will enable more seamless travel between multiple transport modes.



### Sharing economy and AVs

Traditional models of ownership are changing and as AVs become commonplace they have the potential to change how we move around our cities. Shared AVs could have a big impact on how road space is used, as they will travel in closer proximity and could be hailed on demand, 24-hours a day. Further, roads could be narrower, car parking could be removed, and roadside signage could be reduced. Shared AVs could also contribute to decarbonisation goals. However, if privately-owned cars are upgraded to privately-owned AVs, congestion could worsen. The widespread adoption of AVs will depend on a number of factors, including technological advances, cost reductions, safety, public attitudes and policy and legal responses.



### Logistics consolidation

The rise of e-commerce is increasing the number of deliveries in cities, resulting in rising road congestion. Combating this will require more efficiency in freight and servicing. Consolidation centres can increase the efficiency of goods delivery, and help reduce traffic and air pollution levels in city centres. There could be opportunities to combine delivery and personal mobility solutions, as well as make logistics more responsive and efficient. Autonomous freight systems could also enable a shift to night-time servicing.



### Economic models and partnerships

In many cities, the provision of transport infrastructure has traditionally been the responsibility of government because it is characterised as a 'public good'. This is now changing, with the private sector taking a greater role in providing infrastructure projects. However, there needs to be a balance between public good and commercial viability. New partnerships and economic models could emerge, shifting the remit of transport authorities.



### Public opinion

Climate change, energy shocks, economic crises and political upheavals will continue to foster public dissent and political activism. Public opinion will also have an influence on how new services are implemented and how they are used and regulated. The key for policy will be to keep up with technology and consumer demand for new services.

## Key uncertainties and workshop reflections



Business models

The collaboration between public and private entities to provide demand-responsive transport could take a number of forms. The solutions are likely to be dependent on their unique context.



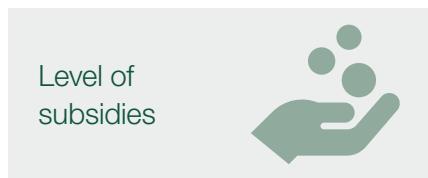
Autonomous Vehicle timing

Full autonomy is estimated to be between three and 13 years away, but remains uncertain. While some benefits may start to be seen by the 2020s or 2030s, most benefits will only arrive when AVs are common and affordable in the 2040s to 2060s.<sup>6</sup>



Government policy

Regulatory and policy issues have the potential to stand in the way of innovation, inhibiting rather than encouraging risk taking and slowing the deployment of new technology.



Level of subsidies

Significant cuts to public transport subsidy budgets are creating a number of challenges. The allocation of subsidies will need to be considered to broaden the impact of transport infrastructure.



Inclusiveness

There is uncertainty about how we ensure that demand-responsive solutions are accessible and inclusive for all.



UK connectivity

Transport infrastructure is vital for good connectivity between regions. It will need to be designed holistically in order to be interoperable and to work efficiently.

## Vision – what good looks like

“*People don't necessarily want competition; they want the benefits of competition, but they also want services delivered in a way that protects them from fragmentation and complexity.”*

**-Giles Clifford, Gowling WLG**

A new understanding of travel as seamless, multi-modal and continuous will replace traditional notions of moving from A to B. To do so, successful urban mobility systems will foster demand-responsive transport (DRT) to complement their existing networks. This will result in faster journeys, less congestion and pollution, and a more accessible city.

Smartphone penetration and the effective use of real-time data will enable a new era of personalised journeys across various modes. The next generation of journey planners will offer bespoke travel options across a range

of measures, such as affordability, speed or convenience, with shared on-demand and AV alternatives integrated as standard. Barriers between different providers and urban authorities will have been removed, allowing integrated ticketing across different transport modes and between different cities.

Successful transport systems will operate as a network of ‘civic’ transport, combining both public and private providers. Effectively implemented, DRT will make better use of existing infrastructure. Dynamic routes and flexible capacity will make the whole network more efficient and increasingly



resilient to extreme weather, security alerts and fluctuations in demand. Alongside this, new policies and business models will support innovation by commercial operators, with MaaS offerings supported by progressive city authorities and by consumer demand.

Effective distribution of DRT across cities will improve efficiency. This will affect both a city's transport network, but also its available road space and resource use. Less reliance on private vehicles will reduce parking requirements and traffic, while incentives for shared mobility will result in fewer vehicles and less energy use. Similarly, flexible and distributed on-demand transport systems will offer improved access to older and younger people, and to communities otherwise isolated by income or geography. By effectively democratising transport across the city, DRT will enable greater access to opportunities and ultimately fairer

economic distribution. Successful cities will make sure that services remain affordable, through subsidy or commercial partnerships.

The transition to AVs will be managed through effective regulation, investment and partnerships. Crucially, self-driving vehicles will be shared and electric, which will multiply the benefits that AVs offer, including increased road safety, reduced private car use and ownership, reduced congestion and improved air quality.

Lastly, DRT will transform freight and commercial vehicle use. Successful cities will partner with private delivery companies and other organisations to establish consolidation centres. These will manage the efficient distribution of freight to inner-city areas in smaller carbon-free vehicles. A shift to night-time delivery will be underpinned by AVs and incentivised by a supportive policy environment.



#### CASE STUDY

### Reactive public bus route prototype

London, UK

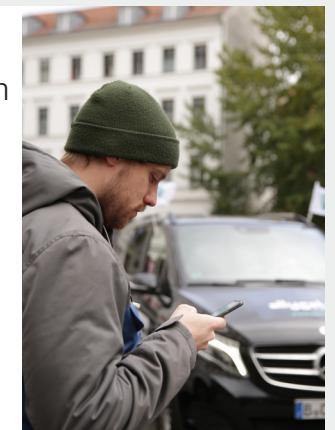
In autumn 2017 route planning app Citymapper operated a pop-up commercial weekend night bus service in east London. The two-month pilot project was approved by Transport for London and used a 30-seat shuttle bus stopping at conventional bus stops. The CM2 or 'Night Rider' route was based on passenger demand data and analysis of 'gaps' in existing provision. Collaborations such as these could inform truly dynamic bus routes based on real-time demand.

#### CASE STUDY

### Public on-demand ride-sharing platform

Berlin, Germany

Door2Door provides public transport authorities with the tools and analytics needed to build their own ride-sharing and on-demand services, complementing mass transit and reducing car use and congestion. Focusing on public transport providers as the key client allows holistic integration across transport modes.



#### CASE STUDY

### Multi-modal personal mobility planner

Paris, France

Vianavigo is a free travel planner app developed by Île-de-France Mobilités, the transport authority that controls the public transport network in Paris. It combines live train, metro, tram and bus data with options for shared bikes, wheelchairs and walking, as well as from 17 carpooling companies across the region. Vianavigo's agnostic approach to both transport providers and mode of travel puts their users first, and is another step towards seamless multi-modal journeys.



# 3

## Do the economic fundamentals of urban transport systems still add up?

“If you remove the cost of the driver, taxis can start to compete with public transport. This leads to a double whammy: limited road space, and not enough vehicles to satisfy demand. It is important to take advantage of what AVs offer, but to mitigate some of the problems.”

—Shashi Verma, Transport for London

### Discussion summary

Changes in the economics of urban transport could lead to transformational change in mobility. However, for disruptive — rather than incremental — change to occur there needs to be a radical shift in input costs. Fundamental change in the cost of transport is rare but new technologies, such as AVs or alternative fuels, could enable this change. For example, if AVs remove drivers and reduce fuel consumption, they could become competitive to public transport. However, this could both decrease the economic viability of public transport providers and increase road congestion.

The economics of asset investment will also be challenged. The changing competitive dynamic in cities is seeing private companies disrupt transport with

no investment and low or no-cost assets including bikes and third party vehicles. While there is a huge diversity of companies tackling core transport challenges, many of the companies causing disruption have little knowledge of the economics of urban transport and the public good it provides.

There will be also be challenges in maintaining a commercially-viable mass transit system if income streams are eroded. For example, London has seen an unexpected fall in passenger numbers, with a 5% drop in rail journeys and a 2% drop in tube journeys in 2017.<sup>7</sup> Decreases in revenues — from fares, fuels, parking and taxes — will create big challenges for transport authorities. It could create a downward spiral with reduced ridership, and higher fares for remaining passengers to cover fixed costs.

**“** We will always need to move large numbers of people. Mass transit is still being designed like it's the 1990s, but technology, data and expectations have changed. There is a disconnect between how we plan and manage transport, and the new availability of data.”

—Richard de Cani, Arup

Is there still a need for a system that can provide investment capital for fixed assets? Or can technology open up new or underserved areas of the city without the need for mass transit investment? If we continue to look at mass transit in the conventional way, there is still a need for big infrastructure. However, utilising shared fleets of AVs could lower the costs of journeys and provide competition to traditional modes.

As logistics and delivery account for the largest fleets on UK roads, the rise of autonomous delivery vehicles could lead to efficiencies and new services, such as combining passenger and freight services and shifting more freight to off-peak and night-time hours. The impact of AVs is uncertain, and new models of regulation, collaboration and operation could be required to manage conflicting fleets.

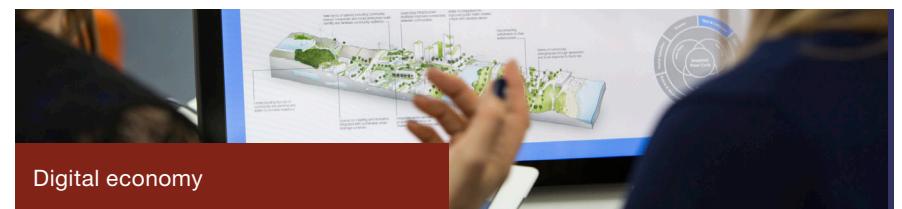


### Evidence and related trends



Congestion cost

Congestion causes inefficient use of space, and has adverse impacts on health. The cost of congestion is predicted to rise faster in the UK than in any other European economy. London is particularly affected, with forecasts for 2030 showing costs to the economy rising to £14.5bn.<sup>8</sup>



Digital economy

Digital technology generates new market opportunities and has a large economic impact across a range of sectors. The emergence of wireless networks, sensors, mobile devices and satellite navigation is further embedding technology into our daily lives, changing the way we move around and consume goods. Digital technology is also enabling the rise of the sharing economy and seamless mobility solutions, which could enhance the efficiency of assets.



## Economic growth

Demand for transport can be impacted by cycles of economic growth and recession. During downturns, the decline of public transport usage tends to result in increasing fares or cuts in service. Low GDP growth is also likely to constrain funding for transport services and infrastructure. Recessions tend to cause cuts to funding, rather than real reform, whereas depression tends to cause longer term reform and restructuring.



## Urban regeneration

Urban regeneration can revitalise neglected or derelict urban areas and bring about positive economic, social, and environmental change. Regeneration includes the revitalisation of brownfield sites and the restoration of the urban fabric, in addition to efforts to rebuild a neighbourhood's economic base. However, there is a risk that changes in mobility are linked to property and land values, and that transport will be vulnerable to property cycles.



## Regional connectivity

Improving inter-regional transport connectivity can lead to economic benefits and encourage multiple successful economic centres. Better linkages between people, places and resources can drive economic activity and boost regional productivity.<sup>9</sup> For example, the introduction of a high speed rail link to the North of the UK could cut the number of unemployed by 36% in Liverpool, 22% in Leeds and 12% in Manchester by 2030.<sup>10</sup>



## Energy efficiency

In the UK, transport is the largest consumer of energy, accounting for 40% of total energy consumption in 2016, compared to 25% in 1980.<sup>11</sup> Of this, 74% of energy consumed is through road transport. Vehicle and engine efficiency improvements, electric vehicles and alternative fuels will help the UK meet its decarbonisation targets. An economic model needs to be created to provide further benefits for reducing energy consumption.

## Key uncertainties and workshop reflections

### Geopolitical uncertainty



The economic impact of Brexit and the resulting regulatory discontinuity could impact the viability of transport systems.

### Technology viability



It is widely assumed that the incorporation of technology into policy will be successful. However, there may be many unintended impacts as well as failures.

### Cybersecurity



Intelligent transport systems will rely on connectivity and data to enable transport modes to communicate with each other, so cybersecurity will be key to the safety of the system.

### Skills and education



UK cities will continue to compete globally for skills, investment and talent. Urban mobility systems, as well as regional connectivity, will be a key part of this as people make choices about where to live and work.

### Devolution



Transport decisions and funding are still mostly centralised in the UK. Outside of London, many local governments lack decision-making power as well as the funding to implement change. The trend is towards devolution, but the effects may be uneven.

### Consumer behaviour



There is uncertainty about the political viability of large scale changes to people's behaviour and how this will impact demand in the real world.

## Vision – what good looks like

To ensure a sustainable range of mobility options — including metro, bus, driverless shuttle and shared cycle schemes — successful cities will develop new income models that capitalise on their initial disruption. Effective transport networks will harness the potential of new market entrants and technologies to develop new revenue streams, for example via MaaS products, while improving customer satisfaction and journey times.

Competition between private providers, licensing, partnership arrangements and — over time — reduced demands on the road network will balance the economic outlook. While challenging, smaller cities' transport authorities in particular will overcome the potential erosion of profitable routes by DRT and AVs through beneficial partnerships and a move away from direct provision.

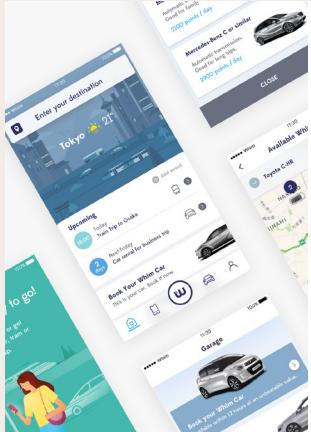
New transport modes will support the regeneration of previously neglected areas of the city. Development will be viable without the need to invest in mass transit infrastructure, with DRT and AVs increasing accessibility regardless of location.

If managed well, this will lead to reduced capital costs for brownfield development, and help to unlock private sector investment.

Digital technology will continue to underpin the rise of the sharing economy. This will improve the efficiency of assets and reduce resource use for both private and public transport providers, thereby reducing costs in the long term. Reductions in private car ownership in favour of shared mobility will see more money available for network solutions such as MaaS. Strong public/private partnerships will make the most of this potential revenue stream, re-investing across the network.

If the focus of urban mobility moves to improving user experiences, this can only be beneficial. In an ideal scenario, this includes active transport such as walking and cycling. This will improve health while reducing traffic, harmful emissions and energy consumption. A successful urban transport system will balance economic sustainability with environmental impact, accessibility and public good.





#### CASE STUDY

## Whim all-inclusive mobility service

Helsinki, Finland

The Whim app, developed by Helsinki technology company MaaS Global, offers unlimited or discounted access to several transport modes for a monthly fee, including bus, taxi, cycle, metro and car hire. It is promoted as a cheaper alternative to owning a car. The subscription service also works as a journey planner, and deals with payment and ticketing. The service's partnership with local transport providers aims to encourage rather than replace the use of existing public transport options.

#### CASE STUDY

## Per-mile road use charging scheme

Oregon, USA

The 'OReGO' pilot project led by the Oregon Department of Transport charged road users 1.5 US cents for every mile driven, with an in-car USB tracking each journey. Participants in the pilot project received a refund for any fuel taxes incurred. Increasing vehicle fuel efficiency and hybrid and electric vehicle use has created a decline in fuel tax revenue for road repair and maintenance. The scheme is an attempt to provide an alternative funding stream for essential road maintenance.



#### CASE STUDY

## Hydrogen-powered passenger trains

Germany

French engineering company Alstom has signed an agreement with Germany to build and deliver 14 hydrogen-powered trains, which will be ready to transport passengers in Lower Saxony from 2021. On a single hydrogen tank, the Coradia iLint trains can cover 1,000km (621 miles) and reach a top speed of 140 km/h (87 mph). Hydrogen-power emits only water during operation, making it an incredibly eco-friendly alternative to diesel.



# 4

## Recommendations for cities

*“How can we break down some of the regulatory barriers between different companies so that we can work with cities more closely? It’s not about a lack of desire, it’s about changing the regulatory frameworks. At the moment it’s a struggle to do this.”*

**-Damian Bown, Citymapper**

It is clear that the transport landscape is in a state of flux. One of the overriding themes to emerge from the discussions was the need for new forms of collaboration between the public and private sectors. Overall, it was felt that cities need to enable a legislative framework

early on, in order to get a handle on change and embrace new technologies. However, this will need to be a dynamic process to prevent obsolescence in a fast-moving environment.



### Policy and powers

- Government must devolve certain powers, including transport and climate change adaptation, to bold and capable city leadership in order to enable city-specific innovation. More local authorities should have directly elected mayors.
- City authorities will need to consider the interdependence of urban systems. They should use their oversight to determine competing demands, and create policy frameworks that address budget silos.
- Cities must work closely with the private sector to capitalise on new technologies, but lobby government and use their own powers to create legislative frameworks that ensure inclusion and equity.
- Cities must assess the policy implications of new business models on the way cities are planned and road space is allocated, and address associated safety and security risks.
- A political consensus must be reached to determine and adhere to a direction of travel. Short-termism will be damaging to the development of effective solutions.



### Seamless journeys

- Cities must create strategies to engage with demand-responsive and ride-sharing services, or plan to provide more seamless journeys with their own new services.
- Cities will need to manage mobility providers to prevent fragmentation and ensure that solutions don’t worsen congestion and inefficiency.
- Cities must employ an agnostic approach to both transport providers and mode of travel. This puts users first, and encourages seamless multi-modal journeys.
- Real integration of public transport and DRT is rare. To be successful, cities must treat DRT as an integrated part of the public transport system. This will require collaboration between the public and private sectors across design, funding and implementation.



## Shared, autonomous mobility

- Cities must make a commitment to promoting the use of low- or zero emission, shared autonomous vehicles and incorporate related policies into their planning cycles. The key for policy will be to keep up with technology and consumer demand for new services.
- Infrastructure should be built and retrofitted with changing models of ownership and shifting travel behaviours in mind. For example, the need for parking could be reduced if shared vehicles replace privately owned cars.
- Cities will need to understand the impact of autonomous vehicles on urban form, including suburbs, at all scales: street, building, district and city.
- As there are still significant technical and regulatory barriers to autonomous vehicles, cities should promote local investment in research and development, facilitate testing on their roads and consider infrastructure (such as location beacons) to support fully autonomous vehicles operating within defined parameters.
- Cities must encourage central government's investment and work on rolling regulatory reforms concerning the legality of autonomous vehicles, product liability, insurance, data protection and cybersecurity.



## Data and analytics

- Cities must consider how they can share data to enable real-time information, unlock new services and create more efficient infrastructure. They should also consider data-sharing agreements between public and private bodies. The security and integrity of the data will be vital.
- Cities must monitor and influence the development of legislative controls on data sharing to make sure that legislative and regulatory barriers do not prevent valid data use to support effective mobility.
- Cities should use real-time data and automated operations to improve on-time performance and shorten passenger transfer times. This will require coordination of competing and siloed data sources.
- Public transport authorities should consider acquiring the tools and analytics needed to build their own ride-sharing and on-demand services.



## Health and wellbeing

- Cities have an important role to play in nudging behaviours and should enable active modes of travel to ensure mental and physical wellbeing. This includes investing in a public realm that supports and encourages active transport.
- Cities should strive to create safe mobility access for everyone, including cyclists, older people, and those with disabilities.



## Freight

- Cities must lobby for robust influence over freight movements and regard freight as an integral part of their transport and mobility remit.
- Policies should support a shift to more responsive and efficient logistics solutions. There is an opportunity to combine delivery and personal mobility solutions, while autonomous freight systems could also enable a shift to more night-time servicing.



## Tax and incentives

- Governments will need to consider alternative funding streams for infrastructure repair and maintenance, given the expected fall in revenues from fuel taxes, for example, through pay-per-mile charging or vehicle miles travelled tax (VMT).
- Larger scale government policies should consider restrictions and incentives to limit the growth of private cars. For example an increase in vehicle registration tax, pricing incentives for EVs or hybrids, restrictions on vehicle licences, and banning of private vehicle use in cities.
- Cities will need to consider strategic pricing access to infrastructure as a potential response to concerns about the introduction of autonomous vehicles. These could cause induced travel (an increase in capacity that is quickly filled by additional traffic) and unintended sprawl.

# Urban mobility in future cities

How our changing cities could incorporate the transport solutions of tomorrow



1

## Mobility as a Service

Various forms of transport — public and private — will be integrated to bring planning, booking and payments onto one platform. This creates a seamless mobility system.



2

## New modes of transport

Rapid technological change will enable new modes of transport, such as the Hyperloop or passenger drones, which will drastically change perceptions of distance and time.



3

## Autonomous transport

Public transport will be largely automated, including driverless pods, trains and metro systems. This will increase efficiency and decrease congestion.



4

## Real time, open data

Opening up data assets enables the development of analytics and software for travel information and services, improving forecasting and reliability.



5

## Robotics and drones

Autonomous robots and drones will be used for a number of functions including the monitoring and maintenance of infrastructure, traffic management and package delivery.



6

## Freight and logistics

Automated freight solutions, including vans and micro-mobility options, coupled with urban consolidation centres will create efficiencies and prevent congestion.



7

## Active transport

The public realm will be well designed to encourage walking and cycling. This will enable healthier transport choices to improve the health and wellbeing of city residents.



8

## Demand-responsive transport

Shared transport services, available on demand, will use fleets of vehicles to transport people along flexible routes, opening up new areas of the city.



9

## Inclusive design

Urban and transport planning will prioritise inclusive design and accessibility, to adapt to and prepare for the needs of a larger cohort of older people, as well as those with disabilities.

## Abbreviations and definitions

**AV:** Autonomous vehicle

**Data mining:** the process of extracting usable data from large volumes of raw data to identify patterns and solve problems

**DRT (Demand-responsive transport):** shared transport services that are available on demand, using fleets of vehicles to transport people along flexible routes

**EV:** Electric vehicle

**MaaS (Mobility as a service):** the integration of various forms of transport into a single mobility service, accessible on demand

**Sharing economy:** a flexible economic network that allows people to share resources with one another, often via the internet, at significantly lower costs than traditional models

## References

1. UK landscape at a glance, by statistic:
- 1.1 Department for Business, Energy & Industrial Strategy (2017). 2016 UK Greenhouse gas emissions.
- 1.2 British Heart Foundation (2017). Physical Inactivity and Sedentary Behaviour Report.
- 1.3 Mayor of London. London Infrastructure Plan 2050: Transport Supporting Paper
- 1.4 Department for Business, Energy & Industrial Strategy (2018). Government agrees landmark Sector Deal to establish UK as world leader in future of mobility.
- 1.5 Centre for Economics and Business Research (CEBR) (2017). The economic effect of road investment.
- 1.6 Department for Transport (2017). The UK Plan for Tackling Roadside Nitrogen Dioxide Concentrations.
- 1.7 INRIX and CEBR (2014). Annual cost of gridlock in Europe and the US.
- 1.8 HM Treasury (2017). Autumn Budget 2017: Philip Hammond's speech.
2. UK Autodrive and Gowling WLG (2018). Building the Road Infrastructure of the Future for Connected and Autonomous Vehicles
3. Department for Transport (2017). British Social Attitudes Survey 2016: Public attitudes towards transport
4. Edwards, T. (2018). What's to blame for a fall in passenger numbers? BBC News
5. Statista (2018). Forecast of smartphone user numbers in the United Kingdom (UK) from 2015 to 2022.
6. Litman, T. (2017). Autonomous Vehicle Implementation Predictions Implications for Transport Planning. Victoria Transport Policy.
7. Edwards, T. (2018). What's to blame for a fall in passenger numbers? BBC News
8. INRIX and CEBR (2014). Annual cost of gridlock in Europe and the US.
9. RSA (2014). Connected Cities – the Link to Growth.
10. White, A. (2015). The HS3 effect: What high speed rail in the North could do for your city. The Telegraph.
11. Department for Business, Energy & Industrial Strategy (2017). Energy consumption in the UK.

## Participants and contributors

London Transport Museum, in collaboration with Arup, Gowling WLG and Thales UK, held a series of thought-provoking discussions for leading thinkers and decision-makers to consider the challenges and opportunities facing our urban transport systems. Participants at the three roundtables and the subsequent workshop are listed below. We thank them for their invaluable insights and contributions.

Malcolm Turner Director <i>Alan Baxter &amp; Associates</i>	Tom Colthorpe Researcher <i>Centre for London</i>	Russell Goodenough Client Managing Director and Head of Transport <i>Fujitsu UK &amp; Ireland</i>
Emil Hewage Founder <i>Alchera Technologies</i>	Ben Rogers Director <i>Centre for London</i>	Sofia Taborda Urban Mobility Consultant
Tom Butler Editor <i>Arup</i>	Richard Sanderson Director, Transport Planning <i>CH2M</i>	Simon Craven Special Advisory <i>Go-Ahead Group</i>
Susan Claris Associate Director, Transport Planning <i>Arup</i>	Damian Bown Director Business Development <i>Citymapper</i>	Benedict Taylor Head - Transport and Infrastructure <i>Government Office for Science</i>
Richard de Cani Head of UKMEA Planning <i>Arup</i>	Andrew McDougall Head of Communications <i>Citymapper</i>	Giles Clifford Partner - Transport & Urban Regeneration - Head of Rail <i>Gowling WLG</i>
Lynne Goulding Senior Foresight + Research + Innovation Analyst <i>Arup</i>	Richard Bruce Director Energy, Technology & Innovation <i>Department for Transport</i>	Matt Hervey Director, Intellectual Property and Chair of the Automotive Technology Team <i>Gowling WLG</i>
Josef Hargrave Associate Director / LTM Futures Fellow <i>Arup</i>	Stephen Bee Policy & Strategy Manager <i>Drive Now</i>	Claire Terry Business Development Manager <i>Gowling WLG</i>
Gillian Iversen Technical Lead, Data Insights <i>Atkins</i>	Giles Fearnley Managing Director <i>FirstGroup UK Bus</i>	Julia Thomas Managing Director <i>Green Tomato Cars</i>
Brigid Fox Sustainable Transport Campaigner <i>Campaign for Better Transport</i>	Christopher Snelling Head of National & Regional Policy and Public Affairs <i>Freight Transport Association</i>	Barrie Cottam Business Development Manager <i>Hitachi Rail Europe</i>
Antony Lain Managing Director, TfL Account <i>Capita Group PLC</i>		

James Nettleton Head of Seed <i>InMotion Ventures</i>	Tom Godsmark Senior Transport Planner <i>Mott MacDonald</i>	Rana Ilgaz Business Technology Strategies Manager <i>Transport for London</i>
Duncan Wilson Director, ICRI Cities <i>Intel ICRI Cities</i>	Tom Van Vuren Divisional Director <i>Mott MacDonald</i>	Iain Macbeth Senior Foresight Manager <i>Transport for London</i>
Nicholas Foxon Regional Development Manager <i>JCDecaux</i>	James Angus Head of Analysis and Forecasting <i>Network Rail</i>	Shashi Verma Director, Customer Experience <i>Transport for London</i>
John Dickie Director of Strategy & Policy <i>London First</i>	Abhishek Sen CEO and Co-Founder <i>NumberEight</i>	Alex Williams Director of City Planning <i>Transport for London</i>
Tony Travers Director, Greater London Group <i>London School of Economics</i>	Stephen Glaister Chair <i>Office of Rail and Road</i>	Mike Waters Head of Strategy & Policy <i>Transport for West Midlands</i>
Katie Jemmett Corporate Membership Manager <i>London Transport Museum</i>	Anete Apine Technology & Innovation Officer <i>Society of Motor Manufacturers &amp; Traders</i>	Toby Hiles Director of Strategic Development <i>Transport Systems Catapult</i>
Sam Mullins Director <i>London Transport Museum</i>	Matt Winfield Director <i>SusTrans</i>	Ron Oren Principal Strategy Analyst <i>Transport Systems Catapult</i>
Wesley Salton Head of Development <i>London Transport Museum</i>	Kimberley Abbott Engineering Innovation Lead <i>Thales UK</i>	Peter Bell Technology & Innovation Director <i>Trapeze</i>
Claire Williamson Assistant Director, Marketing & Development <i>London Transport Museum</i>	Philo Daniel Head of Strategy & Marketing <i>Thales UK</i>	Tim Porter Managing Director <i>Trapeze</i>
Tim Kidd Government Industry Solutions Lead <i>Microsoft UK</i>	Mark Garrity Strategy, Sales & Marketing Director <i>Thales UK</i>	Ben Bell Public Policy Manager UKI <i>Uber</i>
Fiona Nolan-Rodrigues Central Government Account Director <i>Microsoft UK</i>	Sharon Hedges Franchise Programme Manager <i>Transport Focus</i>	Kieran Harte Head of Cities, Midlands, South West, Scotland, Wales, Ireland & NI <i>Uber</i>
Alex Smith Industry CSA <i>Microsoft UK</i>	Matthew Hudson Head of Strategy: Technology and Data <i>Transport for London</i>	Brittany Walcutt Campaigns and Partnerships Lead, UK and Ireland <i>Uber</i>
Ellen Wilson Government Industry Solutions Lead <i>Microsoft UK</i>	Michael Hurwitz Director of Innovation <i>Transport for London</i>	

## Contact

### London Transport Museum

Katie Jemmett  
Corporate Membership Development Manager  
katie.jemmett@ltmuseum.co.uk

Claire Williamson  
Assistant Director, Marketing & Development  
claire.williamson@ltmuseum.co.uk

### Arup

Josef Hargrave  
Associate Director  
josef.hargrave@arup.com

Richard de Cani  
Head of UKMEA Planning  
richard.deCani@arup.com

### Gowling WLG

Giles Clifford  
Partner - Transport & Urban Regeneration - Head of Rail  
giles.clifford@gowlingwlg.com

Matt Hervey  
Director, Intellectual Property and Chair of the Automotive Technology Team  
matt.hervey@gowlingwlg.com

Dawn Beddard  
Corporate Communications Manager  
dawn.beddard@gowlingwlg.com

### Thales

Philo Daniel  
Head of Strategy and Marketing  
philo.daniel@uk.thalesgroup.com

Gayna Hall  
Head of External Communications  
gayna.hall@uk.thalesgroup.com

## Photo Credits

Cover © Arup  
p8-9 Timeline: 1829 Henry Charles Moore, Public Domain, 1830 Original artist unrecorded; reproduced Gibbon, Richard (2010) Public Domain, 1836 Anonymous - Illustrated London News PD, 1863 Hodson, Samuel John V&A Collections accessed 20 May 2012 Public Domain, 1883 Unknown - Daimler.com, Public Domain, 1903 John T. Daniels, Public Domain, 1908 Ford company, USA, Public Domain, 1935 © Transport for London, 1968 (1960s Postcards) Seven Sisters Station, Victoria Line Public Domain, 1984 MaltaGC, CC BY-SA 3.0, 2003 Frank Murrmann, Wikimedia, Public Domain, 2010 Moshrunners, Wikimedia, CC BY-SA 3.0, 2012 Sam Churchill, Flickr, CC BY 2.0, 2016 © Amazon, 2017 © hamdan.ae  
p10 © Thomas Graham / Arup  
p12 © Peter Heeling  
p13 top Martin Pettitt, Flickr, CC BY 2.0  
p13 bottom © Arup  
p14 top John Fielding, Flickr, CC BY 2.0  
p14 © Transport for London  
p15 top Andrew Pilloud, Flickr, CC BY 2.0  
p15 bottom Keith Ellwood, Flickr, CC BY 2.0  
p17 Debbie, Flickr, CC BY 2.0  
p19 top Jeffrey Beall, Flickr, CC BY-SA 2.0  
p19 middle Falco Ermert, Flickr, CC BY 2.0  
p19 bottom © Slide Bristol  
p20 Nicky Rowbottom, Flickr, CC BY 2.0  
p22 © James Prestage / Arup  
p23 top Garry Knight, Flickr, CC BY 2.0  
p23 bottom Pete Birkinshaw, Flickr, CC BY 2.0-  
p24 top Dilu, Wikimedia Commons, CC BY 2.0  
p24 bottom Matt Buck, Flickr, CC BY-SA 2.0  
p25 top Masakazu Matsumoto, Flickr, CC BY 2.0  
p25 bottom Michael Gwyther-Jones, Flickr, CC BY 2.0  
p27 Pxhere, Public Domain  
p28 Sludge G, Flickr, CC BY-SA 2.0  
p29 top © Citymapper  
p29 middle © Door2Door  
p29 bottom © Vianavigo  
p31 Hanno Rathmann, Flickr, CC BY-SA 2.0  
p32 © James Prestage / Arup  
p33 top Sheri, Flickr, CC BY-SA 2.0  
p33 bottom © Arup  
p34 top Gavin Houtheusen/DFID, Flickr, CC BY 2.0  
p34 bottom bvi4092, Flickr, CC BY 2.0  
p35 top Alan Stanton, Flickr, CC BY-SA 2.0  
p35 bottom Noya Fields, Flickr, CC BY-SA 2.0  
p37 © Thomas Graham / Arup  
p38 top © Whim  
p38 middle Doug Kerr, Flickr, CC BY-SA 2.0  
p38 bottom Frank Paukstat, Flickr, CC BY-SA 2.0  
p39 © Paul Carstairs / Arup  
p40 Hernán Piñera, Flickr, CC BY-SA 2.0

## Acknowledgements

*Authors*  
Lynne Goulding, Arup  
Tom Butler, Arup

*Graphic Design*  
Mark Pearsall, Arup  
Ahmad Harun, Arup

*Project Leads*  
Katie Jemmett, London Transport Museum  
Josef Hargrave, Arup

## About Arup

Arup is the creative force at the heart of many of the world's most prominent projects in the built environment and across industry. We offer a broad range of professional services that combine to make a real difference to our clients and the communities in which we work. We are truly global. From 80 offices in 35 countries our 13,000 planners, designers, engineers and consultants deliver innovative projects across the world with creativity and passion.

Founded in 1946 with an enduring set of values, our unique trust ownership fosters a distinctive culture and an intellectual independence that encourages collaborative working. This is reflected in everything we do, allowing us to develop meaningful ideas, help shape agendas and deliver results that frequently surpass the expectations of our clients. The people at Arup are driven to find a better way and to deliver better solutions for our clients.

We shape a better world.

Cities are a magnet for people as centres for jobs, economic activity and innovation, and urban mobility systems lie at the very heart of what makes cities attractive and viable. However, urban transport is facing an urgent set of challenges as a number of social, technological, economic, environmental and political impacts place further stress on already straining systems.

New business models and technologies are emerging to try and solve these challenges, but there are huge uncertainties about how these will impact cities over the long term and whether they will move ahead of customer acceptance and regulatory frameworks.

Over the course of 2017, the Interchange programme at London Transport Museum, in collaboration with Arup, Gowling WLG and Thales UK, sought to drive a conversation around some of these issues and to focus attention on the speed and complexity of the changes occurring in the sector.

This report reflects on these conversations and presents some of the different views that emerged.

# ARUP

13 Fitzroy Street  
London W1T 4BQ  
[arup.com](http://arup.com)  
[driversofchange.com](http://driversofchange.com)  
© Arup 2018