UNIVERSITY OF CAMBRIDGE

CSaP centre for science and policy

Centre for Science and Policy Policy Workshop Report

The Future of Mobility: Exploring social and demographic issues and key trends in mobility

Government Office for Science

Foresight

22 February 2017
Pitt Building and Trinity Hall, Cambridge

Summary

The Centre for Science and Policy (CSaP) organised a Policy Workshop in support of the UK Government Office for Science's Foresight Project on the Future of Mobility.

This report has been prepared by Anna Fee, CSaP Policy Intern, and captures the views and ideas generated and discussed between participants during the workshop.

CSaP Team

- Robert Doubleday (Executive Director)
- Anna Fee (Policy Intern)
- Jackie Ouchikh (Head of Programmes)
- Steven Wooding (Lead for Research and Analysis)

The Government Office for Science, led by the Government Chief Scientific Adviser Sir Mark Walport, is undertaking a Foresight project on the Future of Mobility. This project will bring together cutting-edge academic research, industry expertise and policy making to consider the future transport landscape. Foresight projects last about 12 months and investigate complex cross-cutting issues where new or emerging science can inform policy. The project will work with policy makers to consider what this evidence base means for policy development in their area.

A key element of this work on transport will be to use existing and the latest academic research, building a robust evidence base on how transport demands and provision could look over the coming decades. Further to this, by assessing and prioritising key trends in mobility, a set of future scenarios will be developed and their consequences analysed. Among other themes, the project will examine the social and demographic drivers changing the future transport landscape.

Purpose of the workshop

- To provide participants with an opportunity to share their latest research and policy insights, exploring social and demographic issues and key trends in mobility, and discussing areas of uncertainty.
- To help identify critical uncertainties, as well as any potential issues GO Science should be investigating in detail.
- To develop an understanding of the social and demographic trends and drivers of change shaping the transport system of the future and consider these in the context of emerging technologies.
- To gain insight into people's behaviours and attitudes toward mobility.
- To assess which social changes are certain and identify which are less certain and to think about these through the lens of different scenarios.

The main focus of this workshop was social and demographic issues. Other issues around mobility are being considered elsewhere.

Agenda

- 16:00 Arrival and tea
- 16:15 Welcome and Introductions (Dr Rob Doubleday, CSaP)
- 16:25 Background (Jonathon Keating, GO Science)

  Perspectives:

  - **Professor Sarah Sharples**, University of Nottingham
  - **Dr Amy Guo**, Newcastle University
  - **Dr Caroline Mullen**, University of Leeds
  - **Professor John Miles**, Department of Engineering, University of Cambridge

  Chaired discussion
- 18:40 Walk to Trinity Hall
- 18:45 Networking & drinks (Chetwode Room)
- 19:15 Discussions continue over dinner (Leslie Stephen Room)
- 21:00 Close

Introduction

Jonathan Keating (GO Science) outlined the purpose of the Foresight Project on the Future of Mobility and want they hoped to achieve from the workshop. He explained that the project will run for one year.

There have been many recent advances in technology and transport is undergoing a paradigm shift. The main objectives of this project are to:

- Analyse the existing transport landscape using the best available evidence.
- Build a robust evidence base on how demand and supply will change in the future transport system.
- Look at emerging and rapidly evolving new technologies and their impact on the future transport system.
- Aim to put this in the context of other changes such as economic, environmental, and social and demographic.
- Look at different scenarios, both desirable and undesirable and their consequences.
- Identify critical decision points along the future paths towards these scenarios.

Iarla Kilbane-Dawe (DfT) added that additional aims of the project included using potential future scenarios to test policy. This requires understanding of the uncertainties around things like future transport demand and future long term transport options in the UK over the next 25 years. Another aim is to identify short term issues and prioritise key decisions which need to be made in the next few years.

Presentations

Sarah Sharples (Professor of Human Factors, University of Nottingham)

How transport users use the information available to them

Sarah Sharples has investigated human limitations not only from a cognitive, physical point of view, but also the social context within which they operate, and how these limitations should be used in the development of future technologies. Transport users are exposed to multiple sources of information which, along with their own opinions and experiences, will influence their decisions and transport choices.

Sending personalised information to individuals could help reduce congestion by encouraging them to use alternative routes. However, it will be important for the information to be delivered in a way that the public can understand, trust, and believe will be beneficial to them.

Planning for disruption and non-routine scenarios

People are resistant to change and use past experiences to avoid disruption e.g. the disruption caused by not finding a parking place at the railway station may prevent people from travelling by train in the future. Social media is often useful for circulating information on disruption when rail companies are prevented from revealing details e.g. suicides on railway lines. This can make members of the public more sympathetic towards situations that cause disruption to their journey.

Infrastructure management from a systems' perspective is also important. Vast amounts of data are available but how can this best be used to make decisions to improve efficiency?

Personal data usage

Google gathers real time personal data on road usage which has the potential to influence the choices people make on how they use transport. But should companies also be legally obliged to share personal data that could lead to a conviction? For example, to convict a driver who was involved in an accident whilst using his/her phone.

Key questions – how do we design technology to help influence behaviour effectively and responsibly and how do we manage the tension between tailored personalisation of data with ownership and ethics of using that data.

There is an interest in moving towards open data so rail companies could be encouraged to share their real time journey data to improve the system. However too much regulation can also reduce innovation. Other countries with more relaxed views towards data regulatory frameworks than the UK may choose to move forward with some technologies such as autonomous vehicles and this could put UK companies at a disadvantage.

Amy Guo (Lecturer in Intelligent Transport Systems, Newcastle University)

Impact of age on mobility

12 million people in the UK are aged over 65. A previous study across 33 developed countries, including the UK, showed that those aged over 65 have limited interaction with technologies, likely to be caused by psychological issues and a resistance to change. Technology proficiency is lower in

the over 65s so, if you design technology which is suitable for older people, this technology will be beneficial for the whole population. Older people tend to have more problems with technology. If you work with smaller groups of older people, it is possible to identify more problems than with a larger group of mixed ages. This can help make future technology more accessible to different groups of society.

Some potential changes to help older people engage with technology include having people of a similar age demonstrate how to use the technology. Making older people aware of the impact that age has on driving, and introducing them to other forms of transport could influence their future transport choices.

Caroline Mullen (Institute for Transport Studies - ITS, University of Leeds)

Factors influencing travel choices

Travel behaviour is predictable when you consider household make up, income, cost of transport, congestion time, accessibility and availability of transport. Individuals consider these factors when choosing where to live and work. ITS focuses on the context in which choices are made. Automation could change the way we travel e.g. if people no longer have to drive themselves, will they use cars more frequently?

There are a many uncertainties over the factors which influence day to day travel. There is the uncertainty of housing for many people, particularly those in the rental sector, as well as insecurity regarding jobs and mortgages. This means that people are having to make choices such as whether to have secure housing or own a car. Accessibility to public transport is not an important consideration for many people; the old model of choosing where to live and work based on accessibility of transport no longer seems to apply. People contending with insecure housing will have a car, whether they can afford it or not, so they can still travel to work if their housing situation changes.

Future mobility system design should not increase dependency on private car ownership and need to cater for the complex journeys people have to make. If we shift the focus towards accepting these uncertainties, we can use transport data to make public transport more flexible and journeys less difficult.

John Miles (Research Professor in Transitional Energy Strategies, Department of Engineering, University of Cambridge)

Convenience

The public transport system delivers less utility to fewer people than previously. Taxis are more convenient than buses because they are cheaper, more flexible and more effective e.g. Milton Keynes has 88 buses and 1200 private hire vehicles. Could a future scenario be replacing large, inflexible buses with small, flexible cars which are only in use when needed? The most convenient forms of public transport are the ones which will be used in the future. People will not use park and ride schemes if they have to queue in the rain for a bus which puts them in the same traffic jam they would be in if they were in their own car. If a form of public transport can get a person to their destination quicker than they can get there themselves in their own car, then they will use it.

Discussions

Summary from first session

Key factors affecting mobility

- **Personalisation**
  - Using technology to give people information to improve their experience of the transport system. Allows companies/local authorities/government to ease the pressure on specific transport modes and routes.
  - Activities influence travel and to induce change, transport users need to see that the new system on offer is better than their current choice. Technology can help people transition between different transport modes.
- **Power of convenience**
  - Convenient forms of transport will be more popular but they rely on technology. Too much technology risks social exclusion for some areas of society.
- **Tipping points**
  - Fewer younger people are learning to drive, particularly young men. This is due to housing and employment uncertainties, rising car insurance costs, nd increasingly environment-focused attitudes.
  - Increasing the gap between young city and ageing rural populations. Rural areas and shire towns may become increasingly dependent on cities. Future city transport systems will need to support this.
- **Technology**
  - Like any new technology system, there will be experimentation with different transport models for the next 20-30 years before it settles.
  - Significant reduction in the use of technology in communities such as ageing, reduced ability and reduced affluence. Introducing people to technology earlier can help reduce accessibility problems associated with ageing. Socio-economic factors may be more important.
- **Freight**
  - Road freight is increasingly more important for the transport industry. Changing trends in consumerism e.g. increasing home deliveries increases the demand for freight.
  - 25% of carbon emissions in the UK come from road freight. By 2030 this will be 50% of emissions and by 2050 it will be most of carbon emissions.
  - It's much more difficult to decarbonise freight vehicles than cars.

Key Uncertainties

- **Technological skills**
  - Is it necessary for everyone to have good technological skills or will technology be efficient enough to cross any generation gap and ensure everyone can use it regardless of capability?
- **Continued urbanisation and technology development**
  - Technology may influence how people choose where to live and work. If people had the option to work remotely, they may not need or want to live in cities.
  - Alternatively, autonomous vehicles and new technology may persuade people to live in cities.

- **Cost of convenience of travel**
  - Can current transport systems compete with the prospect of autonomous vehicles providing specific vehicles for specific purposes in the future. Why would you choose to own one car when you could have access to multiple different types of car?
  - Changes to current car ownership and sharing model.
- **Financial cost of future transport**
  - Driverless cars e.g. taxis will become cheaper to run without the cost of a driver. If the cost decreases, people may travel more.
  - Cost is influenced by how competitive the environment is.
- **Future policy changes in other areas**
  - Housing, employment, education, industry, , and environment policy all influence demand, behaviour and attitudes around transport systems, and therefore transport policy.

Case Studies

- Nottingham has the second lowest level of car ownership after London due to its investment in public transport (the city council owns the bus company).
- New Jersey – city chose to give citizens Uber vouchers rather than build a parking lot for park and ride to allow people to park near the station. In this case, Uber was a better option than digging up current infrastructure.
- Boston based start-up company case study; bus/taxi hybrids operate by coordinating requests from different mobile devices.
- Sao Paulo – horrendous public transport and congestion led to trial of helicopter service by Uber for very affluent people. Not environmentally sustainable to replace large mass transit vehicles e.g. buses with multiple smaller vehicles e.g. private hire.

Future Scenarios

- Autonomous vehicles – potential loss of 60,000 drivers' jobs in the UK. US predict 5 million drivers will be out of work by end of 2020s.
- More people learning to drive at later stages in life which may alter their ability to adapt to new road infrastructure. As technologies keep advancing rapidly, older less confident drivers could be problematic in 'smart cities'.
- Ideal mixture of mass transit public transport with fixed times and scheduled and flexible vehicles for random journeys in operation when needed.
- Ideal public transport would save costs for the NHS by getting people to hospital for appointments.
- Drones making deliveries. Safety of autonomous vehicles is important as well as trust in the technology. Goods will be the first to be transported by autonomous vehicles, before people.
- Car-free cities and more challenging; car-free villages
- Setbacks in technology advancements e.g. murders involving autonomous vehicles or drones. For example, the case with Ladbroke Grove for the rail industry in 1999, which set back public trust in rail travel.

Opportunities for the Government Foresight Project

- Address the conflation of electric vehicles and autonomous vehicles and their potential impacts on road freight vehicles – demand for which is increasing. Electric urban freight vehicles could benefit logistics and deliveries, enabling night-time home deliveries with silent vehicles and charging at distribution centres. Electrifying long haul freight is much more challenging.
- Investigate changing attitudes towards car ownership. Car ownership is at its highest level currently but more people are entering into long term leases rather than owning vehicles. Less intensive car ownership will impact the total number of cars in cities. Consider factors affecting wealth of younger people including unemployment, high car insurance costs, high student debts and how this affects their ability or desire to drive.
- Alternative fuel technologies are advancing rapidly. Which areas get these fuels first e.g. aviation industry, the electricity grid or transportation, could be established. If allocated to transportation, the priority is likely to be freight over passenger vehicles. . Renewable energy prices are falling; investigate prospect of households becoming self-sufficient by using solar panels to charge their electric cars. This will impact people's views on transport.
- Changing attitudes through policy – difficult but essential. Current trends of consumerism are heading towards an unsustainable future. Current problems which need addressing include: cheap flights, thermostats in homes set too high, cars as the preferred method of transport over bikes. Responsive policy responses to tipping points e.g. subsidies could be effective.
- Robotics and Artificial Intelligence will increasingly take jobs and reshuffle tasks into new areas of employment. This needs managing and regulating. A decision could be taken to limit impacts of technology on employment over coming decades e.g. semi-automated vehicles could make drivers' lives easier and not take away their jobs.
- Incorporate resilience planning into existing transport infrastructure to help mobilise people into using different transport modes. More resilient infrastructure will be beneficial in areas affected by flash flooding and will prevent wide scale impact on entire country's network through electric line failure for example.
- Anticipate what future users are going to want from their transport system and avoid social exclusion. In the technology development to achieve this, need to navigate socio-economic divides, gender bias and accessibility but also accept that no matter how seamless the interface is between user and technology, some areas of society will always be disadvantaged by certain types of design.

Evening session

Key themes raised for discussion

Cross-departmental issues

- Diagonal accounting: Transport policy is linked to many different areas of policy such as housing, employment, education, planning, digital services, open data and health. For example, education policies dictate pension and disability policies, as well as affecting health status, and available opportunities to keep working in later life and travel to achieve this.

Multi-modal

- Clear pinch points in decision-making highlighted by traveller needs project. A parking space guarantee is required for commuters to leave their cars and board trains. A bike sharing system will only work effectively when there are sufficient bike depots at the different destinations people travel to. Those in charge of managing this need better statistical tools to know where to redistribute bikes and empty spaces, and how to deal with high usage events like sunny days or the Olympics.
- Single transport modes operate in the way most effective for them e.g. rail companies often do not accommodate bikes on trains because they take up space. There is a need to encourage train and bus companies to run services which benefit multi-modal journeys, not just what works for them. If this doesn't happen, travellers will choose to make their journey by car to avoid potential disruption. Transparency of a multi-modal system is important for encouraging people to use it.
- Inter-modal information systems will change as we move towards alternative fuels and charging systems will also change. This will affect travel behaviour in the future. Future information systems also need to include more helpful information on transitioning between different modes to make planning of journeys more seamless.
- Different transport modes develop at different timescales. Pushbacks can affect progress.
- Distinction between journeys spanning different transport modes and crossing organisation boundaries. Systems operators try to optimise their specific single mode of transport. This is different from trying to optimise a single route and all aspects of it.

Effect of social norm on transport

- Social norms take a long time to establish but past government intervention strategies have proven to be very effective e.g. an 85% reduction in drink driving and an increase in wearing seatbelts. The "Think" campaign for road safety was a very successful government intervention throughout a variety of routes: enforcement, regulation, education and behaviour-changing strategies.
- Perception of quality of service and hierarchy of needs is important. Marketing journeys as a pleasurable experience e.g. Virgin Atlantic and banning smoking on trains and buses encourages people to use specific services. However, if a service is poor but individuals need to get to their destination, they will use it if there are no other options.
- Commuters may prefer a longer journey on a single train where they can get more work done and have fewer disturbances than have a shorter journey where they change trains. Example of people adapting to transport scenarios – meetings occurring in car

journeys during congestion in transit to other meetings in Bangladesh; PhD students having meetings with their supervisors during train journeys in the UK; airports are becoming locations for meetings between UK and European colleagues.

- Using transport as a platform rather than a system could influence people to use specific transport modes e.g. schemes where new users can get their friends involved may encourage them to try new modes.

Population and transport needs and key segmentations

- Young and old, rich and poor, urban and rural, all these circumstances affect people's attitudes and behaviours towards transport. Need to ensure equality of access in the future.
- Consumption patterns are changing which is reflected by increasing demand for freight.
- Age and socio-economic status affects willingness to travel and try new forms of transport and technology. Younger people want to be connected to the internet all the time whereas older people want more control over their data and connectivity.
- Attitudes towards data usage are also important. Most people want to be connected to the internet and a previous foresight project deemed connectivity an essential service for today's society, especially for running businesses. However, there may be mistrust over data sharing. Knowledge demonstrations may be required to build public trust in certain technologies and how certain systems use and manage data.

Impacts on supply chain

- 60,000 taxi drivers, 400,000 lorry drivers and 4 million van drivers in the UK. These jobs could be at risk due to autonomous vehicles. Supply chain will also be affected. 1 million people work in manufacturing, many in railways and air travel and also in car maintenance, repair and insurance.. Whilst some jobs may be put at risk by automation, new jobs are likely to be created in other areas.
- Refusing certain technology like autonomous vehicles may result in industry moving elsewhere e.g. Jaguar, Land Rover. Important from a social demographic perspective (previously 6000 jobs were lost when MG-Rover closed down) but these companies also have links with major industries.
- Rapid job loss will be a major short term problem but there is uncertainty over it being a long term problem. It may sort itself out within next 40 years. Job loss for drivers may be widespread across the country (unlike colliery closures in the past creating clusters of unemployment) which could be less detrimental but it could still affect specific social classes..
- Loss of one area of jobs could create need for new jobs in another area. There is currently a shortage in lorry drivers; autonomous vehicles could solve this shortage. Digital manufacturing is gaining popularity with focus on localised manufacturing distribution rather than central manufacturing. Opportunity for attracting industry to the UK.
- Skills shortages may be identified (already a skills shortage within the manufacturing industry). It is critical to consider which skills will be required over the next 10-50 years. New education policies may be required by new industry policies to produce sufficient skills required in the future.

Other points

- Hydrogen fuelled vehicles may not be effective as they are highly intensive in manufacture and transport and use twice as much energy as internal combustion vehicles and a lot more than electric vehicles. Carbon capture and storage using natural gas could make the technology more efficient. Without it, it won't be energetically or financially viable.
- Safety and ethics of autonomous vehicles is important for public perception. Insufficient safety standards could present tipping points in the future and set technology back.
- Walking and cycling as methods of transport haven't received much attention recently. UK roads cater to cars rather than pedestrians and cyclists. To encourage more cycling, roads need to be made safer for cyclists.
- Car free cities could happen with improved sensing instrumentation using live feed data from transport companies which would allow people to make public transport choices more easily. Car free villages will be more difficult to implement as walking and cycling between villages and cities can be dangerous so people choose safer modes of transport like cars.

Participants

- **Stephen Bennett**, Deputy Head of Foresight, Government Office for Science
- **Dr James Canton**, Principal Research Officer, Social and Behavioural Research team, Department for Transport
- **Professor David Cebon**, Professor of Mechanical Engineering, and Director of the Cambridge Vehicle Dynamics Consortium
- **Dr Robert Doubleday**, Executive Director, Centre for Science and Policy
- **Krittika D'Silva**, Computer Laboratory, University of Cambridge
- **Dr Amy Guo**, Lecturer in Intelligent transport Systems, Newcastle University
- **Professor Sarah Harper**, Professor of Gerontology and Senior Research Fellow, The Oxford Institute of Ageing, University of Oxford
- **Dr Debbie Hopkins**, Research Fellow in Low Carbon Mobility and Energy Demand, University of Oxford
- **Dr Jonathan Keating**, Foresight Project Research Officer, Government Office for Science
- **Dr Iarla Kilbane-Dawe**, Head of Partnerships & Engagement, Office of the Chief Scientific Adviser, Department for Transport
- **Professor Paul Linden**, G.I. Taylor Professor of Fluid Mechanics, Department of Applied Mathematics and Theoretical Physics (DAMTP), University of Cambridge
- **Dr Tariq Masood**, Change Management Group, Process Management Group, Engineering Design Centre, University of Cambridge
- **Professor John Miles**, Research Professor in Transitional Energy Strategies, Department of Engineering, University of Cambridge
- **Dr Caroline Mullen**, Institute for Transport Studies, University of Leeds
- **Dr Matthew Niblett**, Director, Independent Transport Commission
- **Charlene Rohr**, Senior Research Leader, RAND Europe
- **Advait Sarkar**, Computer Laboratory, University of Cambridge
- **Professor Sarah Sharples**, Professor of Human Factors, University of Nottingham
- **Dr Marc Stettler**, Lecturer in Transport and Environment, Centre for Transport Studies, Imperial College London
- **Dr Damon Wischik**, University Lecturer and Data Scientist, Cambridge Computer Laboratory
- **Dr Steven Wooding**, Senior Research Leader, RAND Europe
- **Anna Fee** (note-taker), Policy Intern, Centre for Science and Policy

Participant biographies

Stephen Bennett is acting Head of Foresight at the Government Office for Science. Stephen has worked in a variety of roles in government, linked by a common theme of using evidence in policy making. In his current role in the Government Office for Science, he heads the Foresight team which develops evidence to help policy be resilient to future change. Previously Stephen has worked on a range of climate and social policy issues in government, including biofuels sustainability at Department for Transport, climate mitigation at DECC, and tax credits at HMRC.

James Canton works at the Department for Transport as Principal Research Officer in the Social and Behavioural Research team. His core areas of work include leading on social and behavioural research to inform DfT's Road Investment Strategy. James also leads DfT's use of longitudinal research and work on ageing, and has expertise in the application of behavioural insights within a transport context (e.g. to improve road safety). He has an interest in sociological approaches for researching communities and social resilience.

David Cebon is Professor of Mechanical Engineering and a Fellow of the Royal Academy of Engineering. He is Director of the Centre for Sustainable Road Freight and the Cambridge Vehicle Dynamics Consortium – a collaboration between companies from various sectors of industry, joining forces to develop better heavy goods vehicles. David is also a Managing Director of Granta Design Limited which offers Materials Information Technology to engineering enterprises, helping them make better decisions on materials. David's research group focuses on design and dynamics of heavy vehicle suspensions, road damage and the micromechanics of asphalt failure.

Robert Doubleday was appointed CSaP Executive Director in 2012, having previously established the Centre's research programme. His research is concerned with understanding the role of science and technology in contemporary societies (in particular the relationship between scientific advice, policy and democracy), and with developing collaborative methods of working with scientists and engineers on the public policy dimensions of their research.

Krittika D'Silva is a Computer Science PhD student at the University of Cambridge. She works on analyses changes in spatial and temporal polycentrality in urban cities around the world, focussing particularly on mobility modelling and geo-social networks. During her undergraduate degree at the University of Washington, Krittika developed HandWave; an Android library which provides software developers with access to touch free gestures which can be detected by smartphone front facing cameras. This project aimed to address the needs of healthcare workers interacting with mobile devices while handling potentially infectious biological materials.

Amy Guo is a Lecturer in Intelligent Transport Systems (ITS) in the School of Civil Engineering and Geosciences at Newcastle University. Her research covers ITS for Ageing Mobility, Driver Behaviour, Intelligent Vehicles and Low Carbon Transport. She is interested in monitoring driver behaviour, evaluating the effectiveness of technologies in improving road safety and understanding the barriers delaying shift to electro mobility. She was Lead Researcher on In-Vehicle Technologies and Driver Behaviour at Newcastle University (2009-2015) where she completed a project on older drivers; part of the wider Social Inclusion through the Digital Economy (SiDE) project.

Sarah Harper is Professor of Gerontology and Director of the Oxford Institute of Population Ageing. Sarah's recent commitments include serving on the Prime Minister's Council for Science and Technology which advises the Prime Minister on the scientific evidence for strategic policies and frameworks, and chairing the UK government Foresight Review on the future of an ageing population which covered areas such as future technological developments which could benefit older people such as driverless vehicles.

Debbie Hopkins is a Research Fellow in Low Carbon Mobility and Energy Demand, in the Transport Studies Unit (TSU) at the University of Oxford. She has expertise in socio-spatial interpretations, and experiences of environmental issues. At TSU, Debbie is working on a project related to the RCUK funded Research Centre on Innovation and Energy Demand, examining the energy implications of smart mobility and the role(s) of autonomous vehicles in a low-carbon transition. Prior to joining TSU, she was a Research Fellow on the Energy Cultures II research programme at the Centre for Sustainability, University of Otago, New Zealand.

Iarla Kilbane-Dawe is Head of Partnerships and Engagement at the UK Department for Transport. He works with researchers and funders to build collaborations between DfT policy teams and the research community. Iarla trained as an atmospheric physicist and chemist, and has worked on the ozone layer, air pollution science, sustainable transport policy, and innovation in several leading research groups and technical consultancies. His main areas of interest are sustainable transport, implementation of new technologies and public policy.

Paul Linden is Director of Research and Emeritus G.I. Taylor Professor of Fluid Mechanics at the department of applied Mathematics and Theoretical Physics (DAMTP) at the University of Cambridge. His research is in environmental fluid mechanics and his research group are currently developing models of the fluid flow in low-energy buildings, gravity-driven flows in stratified and rotating fluids, internal waves and mixing in stratified fluids. He has previously worked at the University of California in San Diego where he held many prestigious positions including Blasker Distinguished Professor Emeritus of Environmental Science and Engineering.

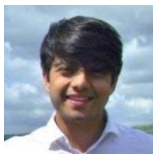
Tariq Masood is a Senior Research Associate based at the Institute for Manufacturing (IfM) and the Engineering Design Centre (EDC), University of Cambridge. He worked as a Knowledge Transfer Partnership (KTP) Associate at the Manufacturing and Materials Department at Cranfield University while based at Rolls-Royce, where he developed global service knowledge to enable feedback to product design, manufacturing and engineering services to reduce operational disruption and maintenance costs. Tariq also worked on digital modelling of robots for aerospace applications at the UK Centre of Excellence in Customised Assembly (CECA) of Loughborough University.

John Miles is Research Professor in Transitional Energy Strategies at the Department of Engineering, Cambridge; a post co-sponsored by Arup and the Royal Academy of Engineering. Prior to this role, John Miles was Group Board Director at Arup, where he was responsible for Arup's worldwide activities in the Energy, Resources and Industry Markets. He was also responsible for business development strategy, client care, and capability development for all of the firm's interests in the areas of energy, water, waste, mining and industry.

Caroline Mullen is a Senior Research Fellow at the Institute for Transport Studies (ITS), University of Leeds. Her research focuses on implications of transport and mobility for social, economic and environmental sustainability, with an emphasis on travel needs, active travel and social and health equalities. This involves development of analytic frameworks for policy development and social research methods especially qualitative methods with professionals and public. She is a member of the Faculty Research Ethics committee and school representative for research ethics, and leader of the ITS Social and Political Sciences research group.

Matthew Niblett is Director of the Independent Transport Commission (ITC), the UK's pan-transport research charity, and a Fellow of the Royal Society of Arts. He oversees the ITC's research portfolio and has presented findings from this research to Ministers and Parliamentary Select Committee enquiries. Matthew holds a doctorate from the University of Oxford and was a Senior Research Associate at the University's Transport Studies Unit.

Charlene Rohr is Senior Research Leader at RAND Europe. She is interested in understanding factors that influence mobility and travel choices. She has been involved in developing transport demand forecasting models in Scandinavia, Europe, Australia, and the UK and has contributed to the design and analysis of transport, health, and communication sector surveys. Her recent projects include a study she led for Innovate UK to develop Future Transport Scenarios to explore the impact of emerging technology on transport; and travel demand studies to quantify demand for long-distance travel to examine key transport policies and whether new roads generate traffic.



Advait Sarkar is a PhD student in the Computer Laboratory at the University of Cambridge. Within the Computer Lab he is a member of the Graphics and Interaction Group. His research interests are currently focused on the usability of analytics. The bigger aim is to improve the usability and accessibility of tools used to perform sophisticated analytics, which involves data management, statistics, and machine learning. Specifically, he is interested in the development of mixed-initiative software tools for data mining and visual data analytics. Besides this, Advait is also interested in transport research, bibliometrics, and applied machine learning in general.

Sarah Sharples is Professor of Human Factors in the Department of Mechanical, Materials and Manufacturing and Associate Pro-Vice Chancellor for Research and Knowledge Exchange in the Faculty of Engineering at the University of Nottingham. She was a grant holder on a long term programme of research for Network Rail examining implications, design and implementation of novel interfaces for railway control and use of rail simulation for human factors research. She leads the University of Nottingham and Leicester Partnership with the Transport Systems Catapult where she is also a Non-Executive Director. She works in the domains of transport, healthcare and manufacturing and is a member of the EPSRC Strategic Advisory Network.

Elisabete Silva is Senior Lecturer (Associate Professor) in Spatial Planning at the Department of Land Economy at the University of Cambridge. Her research interests are centred on the application of new technologies to spatial planning, especially city and metropolitan dynamic modelling through time. She is a Fellow of the Royal Institution of Charter Surveyors and a Member of the Royal Town Planning Institute. She is the co-author of the Ashgate book "A planners' encounter with complexity" (2010); The Routledge Handbook of Planning Research Methods (2014); and "Comprehensive Geographic Information Systems" Elsevier (2016).

Marc Stettler is a Lecturer in Transport and the Environment at the Centre for Transport Studies at Imperial College London. Prior to joining Imperial, Marc was a research associate in the Centre for Sustainable Road Freight and Energy Efficient Cities Initiative, where he completed his PhD. His research aims to reduce environmental impacts from transport using emissions measurement and modelling tools. Marc is a member of the LoCITY 'Policy, Procurement, Planning and Practice' working group and the EQUA Air Quality Index Advisory Board.

Damon Wischik is a Lecturer and Data Scientist at the Cambridge Computer Laboratory. He returned to Cambridge in 2017 to take up a Lectureship in the Computer Laboratory after having spent five years as a data scientist at Urban Engines, a California-based company working on mapping, visualization, reporting, and analytics platforms for transport services. Prior to that, he held a University Research Fellowship from the Royal Society in the Networks Research Group of the Department of Computer Science at University College London. Before this, Damon was a statistical consultant for TauRx Therapeutics; an Aberdeen based start-up working on Alzheimer's disease.

Steven Wooding is Lead for Research and Analysis at CSaP and former Senior Research Leader at RAND Europe. He co-directs the Centre for Policy Research in Science and Medicine, supported by the English Department of Health. Steven's expertise lies in developing and applying measurement frameworks and evaluation tools that capture the diverse range of benefits produced by research in biomedicine, social science and the humanities. He also has expertise in data visualisation and large-scale data processing.