Department for Transport

Science Advisory Council Annual Report 2020

September 2021

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All Science Advisory Council advice, including that reflected in this report, is independent and does not represent the positions of DfT and DfT ministers.

Foreword by DfT Chief Scientific Adviser


What a year 2020 was for science and engineering in government. The COVID-19 pandemic placed science right at the heart of decision-making and has clearly shown the important role science advice has in policy development and delivery. It has been inspiring to see how the science and engineering profession rose to the challenge of responding to the pandemic – as outgoing and incoming Chief Scientific Advisers (CSAs), we are extremely proud of what the profession achieved in 2020. The SAC was a critical part of this, as an invaluable source of expertise and advice to DfT – from the early days in the initial response, to their continued support as the transport sector recovers and rebuilds from it. With transport being one of the first sectors to consider re-opening after the initial lockdown, we were asking all the 'hard' questions first in relation to COVID-19 transmission, possible mitigation measures and establishing the underlying science to understand these.

The SAC provides insight and challenge across the breadth of DfT's areas of responsibility and convenes a wide range of expertise in science, social science and engineering. It brings advice to the CSA to support us in performing our challenge and advice function, and in ensuring science and engineering advice and evidence is robust, relevant and high-quality. The SAC also supports with horizon scanning to identify emerging areas in science, engineering and technology that may be relevant to transport in the medium- and long-term future. Identifying, understanding and utilising science and technology is central to DfT's ability to deliver its ambitious programme of decarbonisation, infrastructure and transport systems improvements and meet the challenges that come with fast-paced innovation. Throughout 2020, the SAC advised DfT on a number of issues relating to COVID-19 response and the decarbonisation agenda, and their insights and input have helped shape activities in these areas.

The year of 2020 was also the last of Phil's six-year tenure as CSA. After joining the Department in 2015, improving the Department's access to external expertise of the type

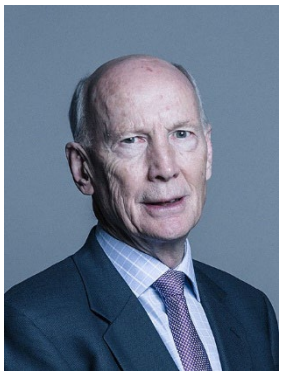
provided by the SAC was a key early priority, and the progress during this period has been remarkable.

We are extremely grateful for all the wisdom, enthusiasm and support that the SAC and its members has given over the years – you have made a very significant impact in DfT and we have learned a lot from you.

Professor Sarah Sharples FIET FIEHF CErgHF, DfT Chief Scientific Adviser

Professor Phil Blythe FREng FIET CEng, DfT Chief Scientific Adviser 2015 to 2021

Foreword by Chair of the Science Advisory Council



The year of 2020 was a very different one for all of us, including for the DfT Science Advisory Council as we swiftly moved to hold our meetings remotely and adopted new ways of working that offered greater flexibility for SAC members to engage with each other and DfT. As the COVID-19 pandemic developed, the SAC brought ideas and advice to support DfT in its immediate response as well as the evidence needs to support the restart and recovery of the transport sector.

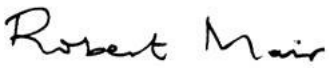
The SAC has also continued to engage with senior policy officials on aspects of DfT's enduring priorities, particularly linked to the vital decarbonisation of the transport system. Technology, social science and innovation are essential tools in meeting this considerable challenge, and the relevant expertise of SAC members will continue to challenge and support DfT's thinking on this priority.

The role of science appears more prominent than ever within DfT, and I welcome the publication of DfT's Science Plan setting out the vision for the science system to support the Department and wider transport sector. I look forward to the SAC further strengthening its role within this system, continuing to join up with the governance structures for science and technology within DfT and the wider transport research and innovation sector.

Crucial to this science system is the role of the Chief Scientific Adviser, and I would like to congratulate Phil Blythe on all he has achieved in strengthening the role of science and technology in DfT during his six years in the Department. He has been a champion of the SAC and a pleasure to work with. I am delighted that Professor Sarah Sharples, a member of the SAC since 2017, has succeeded Phil as CSA.

I will step down as SAC Chair in 2021. It has been a pleasure to hold this role since the inception of DfT's SAC in 2014, but the time now feels right to pass on the baton. I am proud of what the SAC has achieved during my tenure, and I am sure that my successor can further strengthen its role and value to the Department.

Finally, I would like to welcome the new members who joined in 2020 and thank and acknowledge the commitment, contribution and enthusiasm shown by the whole SAC.



Professor Lord Robert Mair CBE FREng FICE FRS

Executive summary

The DfT Science Advisory Council (SAC) provides independent strategic advice and challenge to DfT on a range of science, social science, technology and engineering issues relevant to DfT policy and operations, helping to support the Chief Scientific Adviser (CSA) in ensuring departmental activity is informed by external expertise. SAC members are academic and industry leaders with specialisms relevant to transport.

All SAC advice, including that reflected in this report, is independent and does not represent the positions of DfT and DfT ministers.

This report provides an overview of SAC activities during 2020 and shows the impact of the SAC through providing a summary of the topics discussed and highlighting its key recommendations and advice. Full minutes and outputs from the meetings are provided as annexes.

2020 was a year like no other, and the SAC provided advice on DfT's evidence and research activity in responding to the COVID-19 pandemic and understanding its longer-term impacts on transport and supporting the restart and recovery programme. The other major theme of SAC activity was supporting the imperative to decarbonise the transport system and manage the impacts of this, and this was addressed via discussions on the topics of:

- Influencing travel choices, behaviours, and demand
- Aviation sector skills for zero emission aircraft
- Capital carbon in transport infrastructure

The SAC was also consulted on the development of a strengthened science system within DfT, articulated in the DfT Science Plan.

The SAC continues to provide independent, expert science and technology advice on all DfT priorities, including to grow and level-up the economy, improve transport for the user and reduce environmental impacts as well as continued efforts around recovery from COVID-19. The SAC membership will be refreshed to ensure it continues to include the expertise required to provide high-quality advice to the Department, with an increasing diversity of capabilities and perspectives.

1. Introduction to the Science Advisory Council

The DfT Science Advisory Council (SAC) was established in 2014 to provide strategic advice and challenge to the Department on key science and technology areas. The SAC's membership is formed of academic and industry leaders with specialisms relevant to transport. Biographies of members during 2020 are provided in Annex A.

The SAC provides independent expert advice and challenge on a range of science, social science, technology and engineering issues relevant to DfT policy and operations. Members support the Chief Scientific Adviser (CSA) in ensuring departmental activity is informed by the best external expertise and evidence.

Broadly, the specific activities undertaken by the SAC include:

- horizon scanning, identifying opportunities and risks around emerging science and technology relevant to transport, and advising how DfT can best respond
- advising how science and technology can inform and support policy in specific areas
- advising on the quality of science processes and capability within DfT
- strengthening links with industry and the academic community

When examining science and innovation in specific areas, the SAC works with DfT policy leads to identify and frame the issue, and typically consults additional, subject-specific experts to bring new thinking and evidence into DfT.

This annual report provides an overview of SAC activities during 2020. It provides an outline of the discussion topics held throughout the year and highlights the key recommendations and advice given by the SAC.

2. Summary of SAC discussions

During 2020 the SAC provided valuable independent advice and challenge to DfT in the following areas:

- Influencing travel choices, behaviours and demand
- The use of science and data to inform DfT's response to COVID-19
- Aviation sector skills for zero emission aircraft
- Capital carbon in transport infrastructure

For each of these discussions the key points raised by the SAC are summarised below, highlighting the opportunities and challenges they identified for these areas. The SAC was joined by additional subject matter experts from academia and industry to provide their views and contribute to these discussions (with the exception of discussions on DfT's response to COVID-19).

Further information on these discussions can be found in the minutes and additional outputs from these meetings provided in Annexes B to H.

Annex B is a position paper from the SAC on human factors considerations for the accessibility and safety of highly automated vehicles. This paper was finalised in June 2020, following the SAC's deep dive discussion on this topic at a SAC meeting in November 2019.The SAC's input supported the activity of the Centre for Connected and Autonomous Vehicles - a joint unit of DfT and the Department for Business, Energy and Industrial Strategy - in addressing this topic, helping give direction to policy thinking following the Law Commissions' second consultation within its Automated vehicles project, which included consideration of accessibility.

A position paper (Annex D) with SAC's advice was also produced for the deep dive discussion on influencing travel choices, behaviours and demand. It should be noted that this paper represents the independent views and advice provided by the SAC at the time it was finalised in 2020. It does not represent the position of DfT and ministers' views on this topic, which are represented in the Transport Decarbonisation Plan published in July 2021. Subsequent SAC meetings in 2020 were held online and in a shorter format, for which no position papers were produced.

Influencing travel choices, behaviours and demand – 4 March 2020

Transport is an essential enabler for people to live their lives, providing access to services, education, employment, social interactions and leisure activities. However, high transport demand comes with the risk of negative impacts, including greenhouse gas emissions, poor air quality, and congestion and overcrowding at peak times on all modes of transport. SAC's discussion suggested that interventions to influence travel choices, behaviours and demand are likely to be important to addressing some of these impacts, rather than relying solely on new technologies and increases in capacity.

The SAC was asked for advice on: the key opportunities and mechanisms for influencing sustainable transport choices and demand over the next two decades; existing evidence on the effectiveness of such mechanisms; further required research and innovation; and the potential for wider system-level challenges that could result. The SAC was asked to focus particularly on sustainable transport choices as a contributor to decarbonisation and, although this issue is relevant across transport modes, to focus this discussion on the movement of people on domestic land journeys. The SAC considered the tools and technologies that could support behaviour change, and the existing and required evidence on what mechanisms are likely to be effective.

The SAC recognised that data and connectivity provide both new transport options and opportunities for interventions encouraging sustainable travel choices. Given the very significant challenge of achieving behaviour change at the speed and scale necessary to meet decarbonisation targets, the SAC advised that DfT focus on action to deliver impact soon, informed by a review of existing evidence on what is and is not likely to be effective in influencing travel choices, and accompanied by effective evaluation programmes of new interventions. Strategic roadmapping and outcome-focussed demonstrator projects could develop approaches for specific cities and regions that could then be used as exemplars. To achieve the change required, the SAC's view was that stronger policy levers such as regulation, incentives and pricing are likely to be needed alongside the provision of information and messaging encouraging sustainable travel choices. Approaches could focus not only on individual travellers, but also organisations generating significant travel demand, such as large employers, shopping centres and schools. Finally, the SAC suggested that DfT consider the benefits of providing local authorities with more certain – but possibly target-dependent – long-term funding for sustainable transport infrastructure and innovation.

These conclusions pre-date and do not reflect the full impact of the COVID-19 pandemic on travel and the economy. However, the input from the SAC provided constructive challenge and evidence into the Transport Decarbonisation Plan.

Minutes from this meeting are provided in Annex C. The SAC also produced a position statement of their conclusions from the discussion and independent advice to DfT on this topic, and this is provided in Annex D.

COVID-19 – 8 April and 10 June

The SAC held an ad hoc discussion on 8 April and regular meeting on 10 June (both via videoconference) to discuss the use of science and data to understand the impacts of the COVID-19 pandemic on transport, and to inform DfT's response.

At the April meeting, the SAC was briefed on DfT's use of near real-time travel data to inform the government's COVID-19 response and suggested additional opportunities for data to help understand behaviour during and following the lockdown. The SAC emphasised the opportunities in continuing this increased use of data post-pandemic, and the importance of developing consent for data sharing by building trust and conveying the benefits to the public, private companies, and authorities.

At both meetings, the SAC considered potential future scenarios, opportunities and risks for transport post-pandemic, and advised on DfT's research needs in responding to these. The SAC highlighted the risk of an enduring move away from public and shared transport due to the pandemic, and the need for research to understand people's concerns and how to support passenger confidence. To support decarbonisation and other benefits, the SAC considered it important that any shift away from public transport be directed towards active travel or micromobility options rather than increased use of private vehicles which risk increased emissions and congestion. It was agreed that there would be a short window of opportunity to embed desirable longer-term behaviour changes following the pandemic, and it would be beneficial for DfT's research and policy-thinking to prepare for this. The SAC also advised that DfT's research takes a wide, systems perspective to understand the potential longer-term changes affecting transport demand, including levels of home working, home deliveries, and international business travel, and their wider impacts.

A summary of the April discussion and minutes of the June meeting are provided in Annexes E and F respectively.

Aviation sector skills readiness for zero emission aircraft – 23 September 2020

Aviation is one of the most challenging sectors to decarbonise and is likely to require a range of solutions including new aerospace technology, lower- and zero-carbon fuels, and carbon offsetting measures. Companies globally are developing battery- and hydrogen-powered aircraft which should enable zero carbon emission flight, with substantial state and private sector investment worldwide contributing towards the expected development and commercialisation of gradually larger and longer-range aircraft during the next decade. DfT anticipate such aircraft to be in the commercial market by 2030, and this will entail significant change for aviation and for the skills needed in the sector.

DfT was looking to build their understanding of how the aviation workforce will need to adapt to the development and adoption of zero emission aircraft. As a contributor to this, the SAC was asked to consider the likely impacts on the aviation sector's workforce and government's approach to preparing the sector.

The SAC recognised the uncertainty around the different technological routes and timescales for decarbonisation, leading to uncertainty in the required sector skills. However, they felt there is great scope for developing and moving skills across the

transport sector and more widely, where electric propulsion, hydrogen, hydrogen fuel cells, energy supply and automation are common themes. The SAC suggested that lessons be learnt from skills development supporting the ongoing electrification of the automotive industry, and from major skills changes in industries such as computing. While the aerospace technology ecosystem was well integrated, the SAC felt government could have a role in convening skills across the aviation sector, included clustering and co-locating industry, academia and government to address the most complex challenges. The exciting opportunities to address climate change, support sustainability and technological innovation can be emphasised to attract new talent to the sector, and education and training curricula need to be forward looking while providing key skills that will remain relevant across technological developments.

Input from the SAC on this topic was considered in the development and launch of a Zero Emission Flight Infrastructure project which is researching the requirements for airports to handle electric aircraft. The government published the Jet Zero Consultation in July 2021, which set out the proposed approach and principles to reach net zero aviation by 2050. SAC input also informed the continued development of DfT's Reach for the Sky programme, highlighting the opportunities of technological change to inspire future generations of aviators.

The minutes of this meeting are provided in Annex G.

Capital carbon in infrastructure – 25 November 2020

"Capital" carbon emissions associated with the construction, maintenance and end-of-life of transport infrastructure are currently much less than those from the operation and use of transport infrastructure. However, capital carbon emissions are increasing in the UK and expected to become an increasingly significant proportion of total transport and economy-wide emissions as other sources reduce. DfT is already looking to improve the way that capital carbon is assessed and reported across its major projects to inform decision-making and drive reductions.

The SAC was asked to consider the challenges and opportunities for reducing capital carbon in transport infrastructure, how DfT can enable solutions and what can be learnt from other sectors.

The SAC identified a benefit to improving the assessment and reporting standards for capital carbon across large projects and portfolios, including at the network or whole-transport-system level, so that it can be properly considered in investment decisions. Current major infrastructure projects may not be finished for many years but their whole-life carbon is largely determined by decisions in early project stages, and decisions taken now will influence our ability to achieve net zero by 2050. Given this, and the technological and economic challenges of decarbonising key construction materials including concrete and steel, the SAC emphasised the benefit of action now using the levers and technologies that are currently available, including design efficiencies. Finally, the SAC recognised the ability of DfT, through the scale of its major projects and through regulation, to drive culture change and encourage innovation to reduce capital carbon in the construction sector. To achieve this would require enhanced data skills and high levels of ‘carbon literacy’ from the top and across the industry to deliver this.

The SAC discussion on capital carbon helped DfT to address a number of underlying questions on this topic and acted as a springboard for wider collaboration between DfT and attendees from other government departments and academia. The discussion supported DfT's Carbon Management Programme – which focuses on decarbonising DfT infrastructure projects – and provided insights into other work being done in this area.

The minutes of this meeting are provided in Annex H.

3. Conclusions

During 2020, the SAC continued to support DfT priorities by ensuring that DfT was provided with expert advice on emerging science and technology affecting transport. Key themes of SAC activity over this period were the impacts and response to the COVID-19 pandemic, in both the short and longer term, and the challenges and opportunities associated with the imperative to decarbonise transport.

During 2020, the SAC was also consulted on the development of a strengthened science system within DfT, articulated in the DfT Science Plan which sets out the strategic vision for science in DfT and the Department's ambition to further strengthen the role of science in policy, delivery and decision making. Building stronger partnerships across the sector is one of the three pillars of the Science Plan (alongside people and purpose) and the expert advice and challenge offered by the SAC has a unique role alongside this.

Two members, Paul Newman and Paul Stein, left the SAC in 2020 to join the Prime Minister's Council on Science and Technology, demonstrating both the calibre of SAC members and the relevance of their expertise to the government's strategic agenda. Two new members appointed during 2020, Professor Rob Miller and Dr Dave Smith, have brought wider expertise and fresh thinking into the SAC. This was the start of a new rolling recruitment and refreshment of SAC's membership to enable a breadth of perspectives and capabilities to be maintained. The right membership ensures the SAC is able to provide high-quality strategic science and technology advice to the CSA and act as a 'critical-friend' to the Department.

Annex A: Member biographies

Chair, Professor Lord (Robert) Mair CBE FREng FICE FRS

Professor Lord Mair is Emeritus Professor of Civil Engineering and former Head of Civil Engineering at Cambridge University. He was President of the Institution of Civil Engineers from 2017 to 2018, Senior Vice-President of the Royal Academy of Engineering from 2008 to 2011 and elected to the US National Academy of Engineering in 2019.

He was elected a Fellow of the Royal Society in 2007 and awarded the CBE in 2010 for services to Engineering. In 2015 he was appointed an independent crossbencher in the House of Lords, where he is a member of the Risk Assessment and Risk Planning Committee, and a former member of the Science and Technology Committee.

Professor Lord Mair was appointed Professor of Geotechnical Engineering at Cambridge in 1998. He was the Sir Kirby Laing Professor of Civil Engineering from 2011 to 2017 and Master of Jesus College from 2001 to 2011.

Before his professorship at Cambridge, he worked in industry for 27 years: in 1983 founding the Geotechnical Consulting Group, an international consulting company based in London. He is Engineering Adviser to the Laing O'Rourke Group.

His research group at Cambridge specialises in the geotechnics of tunnelling and underground construction. He has advised on numerous tunnelling and major civil engineering projects in the UK and worldwide, including the Jubilee Line Extension project for London Underground, Crossrail and HS2.

He introduced the technique of compensation grouting to the UK. This was successfully used to protect Big Ben from movement due to the construction of the adjacent Westminster Station and the technique has now been adopted worldwide.

He was closely involved with Crossrail, Europe's largest civil engineering project, and was a member of its Engineering Expert Panel.

Professor Lord Mair also leads the Centre for Smart Infrastructure and Construction (CSIC) at Cambridge, involving the innovative use of the latest sensor technologies to monitor the behaviour and performance of civil engineering infrastructure. He chaired the Royal Society/Royal Academy of Engineering report on shale gas for the government,

published in 2012 and the Task Force Review of Network Rail's Management of Earthworks following the tragic train derailment in Scotland in 2020.

Anna-Marie Greenaway MEI

Anna-Marie Greenaway is currently completing a PhD at the University of Cambridge, following a thirty-year career in international energy. Her PhD is exploring the development of strategic road-mapping frameworks and toolkits to support delivery of net-zero carbon ambitions.

Until September 2020, she was at BP as their Global Director of International University Partnerships. This role encompassed developing and leading BP's strategy for technical and policy research collaborations worldwide including on climate change, alternative energies, transport systems and carbon sequestration.

From 2015 to 2020 she served on the Governance Boards of the BP Institute and the International Centre for Advanced Materials, and the Advisory Committees of the Cambridge Centre for Risk Studies, Scott Polar Research Institute and the Clean Energy Centre at Tsinghua University, Beijing.

Previously, Anna-Marie spent four years in BP’s Group Strategy team, where she led the 2030 Low Carbon Energy Pathways research programme, covering the UK, US, EU, China, India, and Brazil. This involved bringing multi-disciplinary BP teams together with external partners from wider industry sectors, government bodies and leading academics.

Her academic background is in earth sciences, and she holds a BSc from Royal Holloway, University of London, and a master's degree in Sustainability Leadership from the University of Cambridge.

Professor Barry Clarke FICE FGS CEng

Barry Clarke is Professor of Civil Engineering Geotechnics and a founding director of the Institute of Resilient Infrastructure at the University of Leeds. He’s a past president of both the Institution of Civil Engineers (2012 to 2013) and the UK Engineering Professors Council.

He’s currently a member of the governing body of the International Engineering Alliance, the Engineering Council UK International Advisory Panel, and is a founding member of the UK Collaboratorium for Research in Infrastructure and Cities (UKCRIC).

His former national roles include Chair of the UK Engineering Accreditation Board, President of the UK Engineering Professors Council, Chair of the British Geotechnical Association, Chair of UK Ground Forum, and Head of Civil Engineering at Newcastle University.

He was a member of the Board of CITB-Construction Skills, the Construction Industry Council Executive, and EPSRC’s Strategic Advisory Teams for Process, Environment and Sustainability, and Engineering.

Professor Clarke is a civil engineer with interests in the role of engineering in society, the education of engineers, characterisation of ground, application of electrokinetics in groundworks, ground as a source of energy, engineering in complex soils and the application of artificial intelligence in construction practice. He's been retained as an expert witness and advisor to the construction industry on a variety of major projects.

He has helped form 2 spin-out companies from his research in ground characterisation and electrokinetics. He's currently involved in the use of artificial intelligence in the installation and management of utility networks and engineering in complex ground conditions.

Dr Dave Smith FIET

Dave is the Director of Central Technology within the Innovation Hub of Rolls-Royce. In this role, Dave leads a team providing new technological and business concepts, disruptive technologies, management of the group innovation culture and the global University network, as well as leading the environmental strategy for Rolls-Royce.

Before joining Rolls-Royce, Dave was Managing Director of the Ricardo Automotive Engineering Consulting businesses based throughout Europe and with sales teams in Japan, India and Korea.

Previously he was Global Head of PA Consulting's technology consulting, product development and innovation business, and Managing Director of Roke Manor, the communications and software R&D company.

Dave holds a PhD in Physics from Warwick University and is a member of the IET Policy Panel on Innovation and Emerging Technologies.

Professor Nick Pidgeon MBE

Nick is Professor of Environmental Risk and Director of the Understanding Risk Research Group within the School of Psychology at Cardiff University. His research and science policy work is interdisciplinary at the interface of social psychology, human geography, risk research, and the sociology of technologies.

He has worked over the years on safety and the organisational causes of major industrial accidents, on monetary and non-monetary valuation of risk and safety, and latterly on how the public view and engage with environmental and technological risks and sustainability.

His most recent work has focused on topics such as attitudes to nuclear power and renewable energy, people's biographies of everyday energy use including that of transportation, attitudes to future energy-system change, and perceptions of climate change risk. He is currently a co-investigator to the UK Energy Research Centre (UKERC).

Professor Pidgeon has filled numerous science advisory roles, including for HM Treasury, the Department for Environment, Food and Rural Affairs, the former Department of Energy and Climate Change, the National Infrastructure Commission, and the former National Radiological Protection Board.

He is a Fellow of the Society for Risk Analysis, an Honorary Fellow of the British Science Association, and was awarded an MBE in 2014 for services to climate change awareness and energy security policy.

In 2006 he chaired the All-Party Parliamentary Group on Climate Change inquiry, which recommended the setting up of the UK Climate Change Committee.

Before moving to Cardiff in 2006, Nick directed the Centre for Environmental Risk at the School of Environmental Sciences at University of East Anglia. Before that, he held positions at Bangor University and at Birkbeck College, University of London.

Professor Paul Watson FREng

Paul Watson is Professor of Computer Science and Director of the Digital Institute at Newcastle University. He is a Fellow of the Alan Turing Institute and Principal Investigator of the EPSRC Centre for Doctoral Training in Cloud Computing for Big Data.

Before this, he directed the Digital Economy Hub on Social Inclusion through the Digital Economy, which focused on using advanced computing technologies to transform the lives of older people and those with disabilities.

Paul graduated from Manchester University with a BSc in Computer Engineering in 1983, followed by a PhD on parallel computing in 1986.

In the 1980s, as a Lecturer at Manchester University, he was a designer of the Alvey Flagship and Esprit EDS systems. From 1990 to 1995 he worked for ICL as a system designer of their Goldrush MegaServer parallel database server.

In 1995 he moved to Newcastle University, where he has led a range of research projects. His research interest is in scalable information management with a current focus on data analytics and IoT. He also sits on the board of Dynamo North East, an industry-led organisation created to grow the IT economy of the region.

Professor Watson is a Fellow of the Royal Academy of Engineering, a Fellow of the British Computer Society, a Chartered Engineer and a member of the UK Computing Research Committee. He received the 2014 Jim Gray eScience Award.

Professor Peter Jones OBE FCIHT FRGS HonFIHE

Peter Jones is Professor of Transport and Sustainable Development in the Centre for Transport Studies at University College London.

He’s a member of the Independent Transport Commission, the City of London Transport Strategy Board, the South-East Wales Transport Commission, the Dubai Council for Future Transportation, the Hong Kong ERP Advisory Pane and the Chartered Institution of Highways & Transportation (CIHT) Urban Design Panel.

As well as his membership of DfT’s Science Advisory Council, Professor Jones co-chairs the DfT’s Joint Analysis Development Panel.

Professor Jones advises the European Commission and a number of major cities and national governments around the world and was awarded an OBE for services to national transport policy in January 2017.

He is involved in a number of national and international research projects, including being Scientific Co-ordinator of the EU 'MORE' project, which is looking at future pressures on main roads in cities, resulting from socio-demographic changes and technological developments, and how these might be accommodated through more dynamic allocation of road-space.

He also plays a leading role in representing UCL on the EIT Urban Mobility, an EU Knowledge Innovation Community established in 2019.

Professor Jones has a wide range of transport research and teaching interests, covering both analytical methods and policy, including:

- traveller attitudes and behaviour
- travel trends and the determinants of travel demand
- traffic restraint studies
- accessibility studies
- policy option generation
- major transport economic and social impact studies
- public engagement
- development of new survey and appraisal methods
- activity-based modelling and analysis
- advances in urban street planning and design

Professor Ricardo Martinez-Botas FREng

Ricardo is Professor of Turbomachinery at Imperial College London, and Head of the Thermofluids Division in the Department of Mechanical Engineering.

He leads a research group in the area of low carbon vehicles with particular emphasis on highly downsized engines, turbochargers and energy storage systems. He has developed the area of unsteady flow aerodynamics of small turbines, with particular application to the turbocharger industry. The work has attracted support not only from government agencies but also from industry.

Ricardo has a MEng degree in Aeronautical Engineering from Imperial College London. He obtained a DPhil in the Rolls Royce University Technology Centre at the University of Oxford in 1993. He was appointed lecturer at Imperial College in 1994 and became professor in 2012.

He's the current Chair of the American Society of Mechanical Engineers (ASME) International Gas Turbine Institute and a past chair of the UK Universities Internal Combustion Engines Group (UnICEG).

He is a visiting professor in the University Teknologi of Malaysia and at the Nanyang Technical University in Singapore.

Professor Rob Miller FREng

Rob is Chair in Aerothermal Technology and Director of the Whittle Laboratory for turbomachinery research at the University of Cambridge. His research is aimed at reducing the emissions of both air travel and land-based power production, on which he works with a multidisciplinary team and a range of leading companies.

Professor Miller's research interests include compressors and turbine aerodynamics, effects of manufacturing variation, pressure gain combustion for gas turbines, and energy and the environment.

Professor Miller has won the American Society of Mechanical Engineers (ASME) Gas Turbine Award 3 times and the Institution of Mechanical Engineers (IMechE) Thomas Hawksley Gold Medal in 2010.

Before joining the University of Cambridge in 2001, he was a Senior Lecturer at New College, Oxford University, and obtained his DPhil from Oxford.

Professor Sarah Sharples FIET FIEHF CErgHF

Sarah became DfT Chief Scientific Adviser in July 2021, prior to which she was a member of DfT's Science Advisory Council since 2017. She is Professor of Human Factors at the University of Nottingham and from 2018 to 2021 was Pro-Vice-Chancellor for Equality, Diversity and Inclusion.

Sarah's work considers how we can use human factors quantitative and qualitative methods to understand human capabilities and limitations and uses this understanding to inform the design and implementation of novel technologies in complex systems. Her work spans transport, manufacturing and healthcare.

Within transport, she led a long-term programme of work with the rail industry, with a particular focus on the design of work for signallers and controllers. She applied this work within the air traffic control domain and has collaborated in projects which now inform understanding of workload, situation awareness and behaviour strategies in high demand transport control settings.

More recently, her work has focussed on intelligent mobility, taking a systems approach to understanding the information needs and decisions made by travellers across an end-to-end journey.

Sarah has a BSc in Psychology, an MSc in Human Factors and a PhD in Human Factors of Virtual Reality.

In 2018 Sarah was appointed as a council member for the Engineering and Physical Sciences Research Council. She was President of the Chartered Institute of Ergonomics and Human Factors from 2015 to 2016 and was a Non-Executive Director of the former Transport Systems Catapult.

Annex B: Position statement on human factors considerations for accessibility and safety of highly automated vehicles

The conclusions and advice described in this position statement are the opinion of the SAC at the time it was finalised in June 2020. They do not represent the positions of DfT and DfT ministers. These positions may also change over time as new technology, policy, and societal factors emerge.

Introduction

The Department for Transport Science Advisory Council (SAC) met on 20 November 2019 to discuss aspects of the accessibility and safety of automated vehicles (AVs) concerning human factors. Connected and automated vehicles have several significant potential benefits, including improved road safety, improved driving economy (with financial and environmental benefits), and greater access to transport for the elderly and disabled. Some of these benefits apply equally or especially to freight transport, and many factors will affect their successful realisation. On this occasion the SAC was asked to specifically consider how government can ensure that members of the public with diverse needs can safely and effectively interact with highly automated vehicles with no driver, whether as passengers or other road users. Diversity of needs will include physical, sensory, cognitive and behavioural factors. In particular:

- what are the key challenges around making AV-human interactions accessible and safe for all, including the elderly and disabled; what are potential solutions; and what further research and development is needed?
- how should government assist in addressing these challenges, developing solutions, and encouraging industry to deliver accessible and inclusive AVs?

Several subject matter experts from industry and academia joined the meeting to provide their views and facilitate the discussion.

Background

AVs have the potential to significantly improve the accessibility and safety of road transport, but this depends on effective implementation taking account of the diverse needs of users and others affected. Human factors is the discipline concerned with understanding the interaction between humans, machines and the environment in which they operate[1] For a more detailed definition, see the website of the International Ergonomics Association, https://www.iea.cc/whats/index.html. Human factors is a key consideration for AVs with very high levels of automation, because the human driver, with whom a lot of interaction currently occurs, is replaced by an automated driving system. The meeting considered HF around both interactions of passengers with the AV, relating to accessibility, and interactions of the AV with other road users, relating to safety.

The scope of the SAC's discussion was framed by the concept of 'highly automated road passenger services' (HARPS). A HARPS is 'a service which uses highly automated vehicles to supply road journeys to passengers without a human driver or 'user-in-charge'. The vehicle would be able to travel empty or with only passengers on board', Automated Vehicles: Summary of Consultation Paper 2 on Passenger Services and Public Transport, Law Commissions. Unlike at lower levels of automation, passengers would not have any responsibility for the driving task, nor be expected to take over control in response to an incident.

Accessibility of transport for all of society is a priority for government: the Future of Mobility Urban Strategy has as its second principle, 'The benefits of innovation in mobility must be available to all parts of the UK and all segments of society;' DfT's Inclusive Transport Strategy highlights future mobility technology as a key area through which to improve the provision of transport to disabled and older people; and improving access to transport is a strategic priority for the government's Centre for Connected & Autonomous Vehicles (CCAV). In addition, the role of transport in addressing the Ageing Society Grand Challenge was a priority of DfT's then Chief Scientific Adviser, who was keen that the role that automation can play in supporting older people's mobility be better understood. AVs could improve access to transport because they do not make the traditional demands of driving. This would most benefit people excluded from contemporary forms of transport due to an impairment and/or their age, but this requires AVs to be developed with these users' needs in mind. Here human factors considerations relate to physical and cognitive accessibility factors. [1] The SAC did not consider other aspects of accessibility, such as economic or geographical accessibility of service provision, which has been covered elsewhere, including in the review and consultations by the Law Commissions.

AVs also have the potential to improve road safety by removing driver error and poor driving practices, but they will have to deal effectively with complex environments and interactions with other road users. For example, we rely on negotiation with a human driver when crossing the road. If the driver has been removed, how does this negotiation occur? This becomes particularly important to consider when the pedestrian is visually impaired and may not be able to negotiate as other pedestrians can. In the likely short-to-medium-term scenario of mixed traffic – AVs negotiating with non-AVs – it is also especially important that each reacts appropriately to the other.

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[1] See also M Kyriakidis, *et al*, (2019) *A human factors perspective on automated driving,* Theoretical Issues in Ergonomics Science, 20:3, p223-249, DOI: 10.1080/1463922X.2017.1293187.

Key considerations, opportunities and challenges

Key to human factors considerations is having a whole systems perspective, focussed not only on how individuals interact with specific technologies, but considering all actors, technologies and artefacts within a system. This is especially true for AVs as there is such a significant, complex and unpredictable interaction between physical infrastructure, digital technologies, mechanical systems and people within and outside multiple vehicles. There is also a strong social influence, with normative behaviours and perception of risk influencing actions, as well as rules and regulation. Cultural differences, both in different cultural settings and between those of different cultures within a single setting, will also be important. Cultural responses may, at least initially, have a strong regional dependence due to varying levels of exposure to the technology.

Interactions with users - accessibility

The potential benefits of AVs will not be realised if the solutions they provide are not aligned to the needs of society and designed around users, or if their benefits are poorly communicated. The most valuable automated mobility services will be those that meet existing needs or improve on current issues, including those of disabled and older people. Clearly demonstrating how AVs could meet these needs is more likely to improve public trust and appetite for them. People use technology differently, and human-machine interfaces must be adaptable/configurable to individual's physical and cognitive needs, and compatible with accessibility aids. As part of this, the use of voice control may be valuable, although it should not be considered a panacea for all. Having individual preferences stored and usable by the vehicle would be desirable to reduce the burden on the individual. One interaction that needs to be accessible is the user's means to summon and pay for HARPS.

A further example concerns the varying user needs when dropping off/picking up passengers. People with disabilities, or carrying heavy goods, will not be able to walk as far from the vehicle as other groups, so procedures will be needed to ensure that these groups get priority in the allocation of the limited kerb-space at that point in time. Some users will also need the ability to control very precisely the vehicle's stopping position (perhaps with voice commands) to meet accessibility needs, e.g. within centimetres of a wheelchair access ramp.

Research shows that, even if they are not involved in the driving task, people are concerned about retaining some control over the strategic routing and progress of AV journeys. As well as being provided with sufficient information on journey progress and related updates, this is about having the ability to slow, stop or change course during the trip.

Interactions with other road users - safety

AVs must be able to react to complex and varied human behaviour to keep passengers and other road users safe. Firstly, highly automated vehicles must be clearly distinguishable from conventional vehicles in mixed traffic. It will then be crucial to understand how other road users and pedestrians will behave around AVs, including whether AVs will behave like conventional vehicles and how other road users'

assumptions about AVs may change their own current behaviours. It would be inadequate to design AV systems only based on current behaviours and norms.

It is, therefore, critical that data-sets used to train and test these interactions represent the full diversity of other road users and behaviours to be encountered. Accessing sufficient quantities of representative data is a challenge, especially for start-up/smaller companies, and an area where collaboration and government support would be valuable. Relevant behaviours will be affected by geographical and cultural influences, concerning things such as jaywalking and eye contact. AV datasets are frequently sourced from particular areas of the United States which do not reflect locations and use cases in the UK. They also often don't represent interactions with people with reduced mobility, or other road/pavement users with diverse needs, and data including these users at a sufficient level is challenging to obtain.

Safety-relevant data from operating AVs may form one element of the required data-sets, as well as potentially providing other important information to authorities and regulators. Government should lead activity to facilitate sharing of this specific, valuable data for the benefit of all, without compromising companies' commercial competitiveness. Some artificial intelligence systems controlling AVs learn from experience, and there is a strong argument that this learning should not be restricted only to the technology owners.

More generally, government-industry roadmaps plotting the development and regulation of AVs do not always sufficiently reflect the needs of other road users. In particular, pedestrians and cyclists, as vulnerable road users, may have different perspectives from drivers on the acceptability of AVs.

Designing for all

The need to 'design for all' underlies both safety and usability. Too often, design focusses on the needs of narrow groups, sometimes because the designers themselves are not sufficiently representative. Instead, diverse groups of potential AV users and other road users should be involved in the design process through co-design, as identified in the Law Commissions' October 2019 consultation on AV passenger services and public transport. In addition, to understand the full diversity of interactions and needs, it will be important to further develop the evidence base on human behaviours as passengers and as other road users, and to curate and share representative data. User-centred design should include the needs of those living in rural and remote areas, where the proportion of older people is greater and where AVs could provide great benefits, but which may not be as commercially attractive to operators.

Desirability and trust

The potential utility of AVs in delivering accessible and inclusive transport would particularly benefit some in society. Nevertheless, development of a wide commercial market for AVs will also rely on their general desirability – people wanting to use them whether or not they stand to benefit in terms of accessibility – alongside their being relatively affordable and sustainable. This widespread public appetite for AVs remains some distance away and would need to be established in addition to overcoming the remaining technical barriers. This would further motivate commercial development, and

technology developed first for AVs marketed primarily on their desirability will then support accessibility in more functional and affordable vehicles.

Trust in AVs is crucial to engaging all users, including older people specifically. This includes trust in the level of control they have, their security and their privacy and the general comprehension they have of the systems. Different studies have found differing results concerning the level of trust and acceptability of AVs among older people, but some (as well as in work conducted by Aurrigo also presented to the SAC) have observed positive responses and the ability to improve trust to high levels with the right engagement Studies have shown this depends on exposure to the technology being accompanied by accurate and on-going feedback on vehicle actions, an appropriate communication style and making clear the purpose and design of automation in a way that relates to users' goals.

A specific issue concerning trust is how the risks and risk-levels concerning AVs are communicated to the public. AVs will not be risk-free and it will not be sufficient for AV journeys to merely be statistically safer than those with a human driver; because of the loss of personal control and human accountability, passengers and other road users will need to be convinced that they are considerably safer. The building of trust will also need to mitigate the risk that a single/small number of significantly bad incidents will strongly undermine it.

Research gaps

In relation to the key challenges, attendees identified the following research gaps:

Interactions with users – accessibility

- How can artificial intelligence systems, such as AVs, properly respond to individual needs?
- How can an AV be summoned and paid for in a way that is accessible to all?
- How can we prioritise access to kerb-space and other restricted areas for particular groups?

Interactions with other road users – safety

- What specific movements or signals do pedestrians take their cues from when negotiating with a vehicle?
- How might other road users alter their behaviours around AVs compared to conventional vehicles?
- How can the quality and integrity/robustness of training data be assessed?
- How important is it that training data is specifically relevant to the deployment area? Should local data be mandated? Should common data sets be available for all in the UK?

Desirability and trust

- How can the potential improved safety benefits of AVs be successfully communicated? How can these benefits be quantified and evidenced?
- What level of risk is acceptable to the public without compromising trust? How can this risk be communicated clearly, underpinned by evidence?

SAC advice to DfT

To support the safe and accessible implementation of highly automated vehicles, including highly automated road passenger services (HARPS), the SAC recommends that DfT and government:

1. coordinate activities under the Future of Mobility and Ageing Society Grand Challenges to investigate and develop the accessibility benefits of AVs for older people

2. ensure that the needs of those in rural communities are fully considered in the development and future deployment of HARPS, so that they can access the benefits; this could be considered within DfT's work on Future of Mobility focussing on rural communities

3. fund trials that demonstrate the societal benefits of AVs, trials in more complex environments, and trials that safely expose the public more frequently to AV technology

4. ensure all trials and demonstrations have a clear evaluation, data collection and data sharing strategy to provide knowledge and evidence to inform the sector

5. engage with the public in a frank and open discussion about the benefits and risks of AVs, using existing needs to shape the conversation

6. continue to build evidence on human factors underpinning accessibility and safety of AVs for all in society; commission research to fill gaps, including those identified above, focussing particularly on fundamental human behaviour research investigating why road users behave as they do

7. consider how government can assist in facilitating production and wide availability of the required extensive datasets of diverse road interactions and behaviours; one aspect of this is the sharing of safety-critical data from operating AVs without compromising companies' commercial competitiveness

8. seek and use opportunities to learn from relevant activities in other countries, as well as continuing to share UK best practice

Annex C: 4 March 2020 meeting minutes – Influencing travel choices, behaviours and demand

DfT Science Advisory Council

10:00–13:00 Wednesday 4 March 2020

Great Minster House, 33 Horseferry Road, London, SW1P 4DR

Council Members attending

- Prof Lord Robert Mair (Chair)
- Prof Barry Clarke
- Anna-Marie Greenaway
- Prof Peter Jones
- Prof Ricardo Martinez-Botas
- Prof Nick Pidgeon
- Prof Paul Watson

DfT Attendees

- Prof Phil Blythe, Chief Scientific Adviser
- Dr Siobhan Campbell, Head of Central Research Team
- Private Secretary to the Chief Scientific Adviser
- SAC Secretariat
- Head of Academic and International Engagement, DfT Office for Science
- Head of the Transport Research Innovation Board, DfT Office for Science
- Dr Kavitha Kishen, Deputy Director – National Security Science & Research
- Head of Science Plan Strategy & Programme (item 4 only)
- Science Plan Senior Policy Adviser (item 4 only)
- Deputy Divisional Manager, Maritime Environment & Financial Incentives (item 8 only)
- Head of Technology, Maritime Infrastructure People & Services (item 8 only)

Attendees for item 9 only

- Prof Jillian Anable, Professor of Transport and Energy, University of Leeds
- Ali Clabburn, CEO, Liftshare
- Principal Research Officer, Social and Behavioural Research, DfT
- Graham Grant, Head of Transport Investment, Newcastle City Council
- Prof Susan Grant-Muller, Professor of Technologies and Informatics, University of Leeds
- Ted Hayden, Deputy Director – Strategy Unit, DfT
- Strategy Adviser, Strategy Unit, DfT
- Dr Marcus Jones, Principal Consultant in Sustainable Transport, Transport Research Laboratory
- Prof Glenn Lyons, Professor of Future Mobility, University of the West of England
- Dr Bob Moran, Deputy Director – Environment Strategy
- Mark Nicholson, CEO, Vivacity
- Jessica Oppetit, UK General Manager, ViaVan
- Amanda Rowlatt, DfT Chief Analyst
- Science and Innovation Strategy Lead, DfT Office for Science

Apologies

- Prof Sarah Sharples
- Head of DfT Office for Science

These minutes summarise the range of independent views and opinions expressed during the meeting, without generally attributing these to individual attendees. Individual opinions may not be the view of the SAC or group of attendees as a whole. Neither individual views nor SAC advice should be taken as representing the positions of DfT and DfT ministers.

1. Welcome and introductions

1.1 The Chair welcomed the Council members and attendees, and noted the apologies received.

1.2 The Chair informed the Council that both Paul Newman and Paul Stein have been invited to join the Prime Minister's Council on Science and Technology and, as they feel unable to fulfil both roles, have resigned from the SAC. The Chair passed on the thanks of both to the other Members and the Secretariat.

1.3 In light of the above, the SAC's membership was briefly discussed, and it was agreed that the Secretariat would commence a publicly advertised recruitment process for up to four new members (Action 20-03/1). (*Note: this process was delayed due to the impact of COVID-19.)*

2. Review of minutes and actions from November meeting

2.1 The minutes from the November meeting were agreed without any amendments.

2.2 The secretariat provided an update on actions from the November meeting. All actions had been completed. The following points were noted:

- *Action 1 – SAC Secretariat to investigate holding a future SAC meeting at CPC offices in Farringdon as an opportunity to gain further understanding of CPC's activities and how it can support DfT priorities.* The Connected Places Catapult are interested in hosting the SAC for the September or November meeting.
- *Action 3 – Phil Blythe to suggest to the Government Chief Scientific Adviser the idea of holding a cross-government SACs event on decarbonisation.* Phil Blythe had made this suggestion to the GCSA and would follow-up if necessary. The Secretariat took an action to circulate to SAC members a relevant recent letter from the Prime Minister's Council on Science and Technology on the importance of joining up thinking on decarbonisation across HM Government (**Action 20-03/2**).
- *Action 8 – Phil Blythe/SAC Secretariat to approach EPSRC and ESRC to propose a meeting of the SAC with their relevant portfolio managers, to review coverage of transport-related themes and identify any gaps.* This has been raised with EPSRC and ESRC, as well as Innovate UK, with the intention that something be organised in the next six months.

2.3 The Secretariat took an action to make contingency plans for holding the June meeting by videoconference in case it could/should not be held in person due to COVID-19 (**Action 20-03/3**).

2.4 As a brief AOB item, Siobhan Campbell gave an update on the Department's work on appraisal of transport policies and projects, noting recent media coverage on HM Government's guidance on appraisal (the Green Book), which has centred on transport. HM Treasury have announced a review of the Green Book that is expected to focus on ensuring appraisal appropriately reflects the HM Government's agenda of "levelling-up" society and the economy across the UK. DfT have already been reviewing how this can best be done within current guidance and are working closely with HM Treasury ahead of the review. DfT are also thinking about how carbon impacts are valued in appraisal, given the need to adequately reflect the priority of the 2050 net-zero legal target. The SAC noted that infrastructure engineering companies are beginning to offer alternative, lower-carbon (but more expensive) construction plans that mitigate the high embedded-carbon 'costs' of steel and cement, and that there could be a benefit in appraisal judging such options appropriately. The SAC were also interested in how appraisal guidance can appropriately value innovation, and reflect the best scientific evidence in support of benefit/cost valuations. DfT are engaging their Joint Analysis Development Panel (JADP) of external advisers on this work, and the SAC were interested in a potential joint discussion with JADP.

3. Review of draft position paper on Highly Automated Vehicles: Human Factors considerations for accessibility and safety

3.1 This paper followed from the deep-dive on this topic at the November SAC meeting. The SAC made the following comments on the draft paper:

- The paper would benefit from further framing and context at the beginning on the main benefits of highly automated vehicles (HAVs) generally (safety, driving efficiency, supporting rural services, increasing mobility for the elderly/disabled) and the problems they could address, before making clear the limited scope of the SAC's discussion within that. For example, although the SAC discussion focused on accessibility needs of individual users, HAVs could be very beneficial for freight

transport and may be more easily implemented for this use. The paper could also refer to potential topics for further SAC discussions/papers on AVs.
- Rural transport needs were an aspect of the original discussion that should come across more in the paper. This could reference DfT's upcoming work on a Future of Mobility Rural Strategy.
- The paper should include the point that highly automated vehicles must be clearly distinguishable from conventional vehicles in mixed traffic.
- The paper should raise the issue of how an HAV is instructed to stop exactly where required to meet accessibility needs, e.g. within centimetres of a wheelchair access ramp. Could voice control be especially valuable in such scenarios?
- The paper should mention the importance of scenario planning for commercially driven advancements and what this means for policy, including what the future relationship could be between public investment and AV companies, and how the Government could ensure inclusive access and appropriate funding for infrastructure.
- The paper should raise the question of what we can learn from other countries.
- The text of recommendation 5 should clarify what is meant by "evidence base," and what problem(s) it is intended to address.

3.2 The SAC asked the Secretariat to also obtain comments from Sarah Sharples, given her relevant expertise. (**Action 20-03/4**)

3.3 The Secretariat will revise the paper and recirculate with tracked changes for approval. (**Action 20-03/5**)

4. DfT Science Plan

4.1 An introduction was given to the origins, vision and approach for developing the Science Plan. The Science Plan is intended to deliver a cohesive transport R&D programme via the Governments' spending review process, and a strong R&D culture and capabilities across DfT and partner organisations. Work to date has identified three high-level priorities for the R&D programme to support:

- All journeys are net-zero
- People and places have the connections they need
- UK is a global hub for transport innovation

4.2 The SAC was asked to consider:

- Have the right priorities been identified for the Science Plan?
- What R&D activities, investments and programmes does the SAC suggest are prioritised in the immediate and longer-term to achieve these priorities?

4.3 In response, the SAC made the following points:

- Increased coordination with and across DfT's Arm's Length Bodies (ALBs) is important to take advantage of synergies and maximise value, especially given the scale of ALBs' investment in technology and innovation. It was noted that this has already been identified as a key part of the Science Plan work.
- Cross-government coordination is also important to maximise overall value, including considering how transport investment will support the aims of other government

departments. It was noted that the Science Plan work stems from the Government Science Capability Review, which reflects key themes including decarbonisation and the Industrial Strategy, but there is no single cross-government science plan in existence or development. The recently announced Integrated Review of foreign policy, defence, security and international development, will provide some very high-level coordination for science in that sphere, with some relevance for transport.

- Is there potential for things to fall through the cracks between the three priority areas ('buckets') identified? For example, the focus on all journeys being net-zero ought not to result in adverse effects or missed opportunities in relation to air quality and noise impacts. In response, it was stated that problem statements sitting below the headline buckets will capture and address such issues.
- It would be beneficial to identify and emphasis cross-cutting themes across the headline priority areas, such as skills development. The Government target for R&D spend to reach 2.4% of GDP by 2027 could also feature more strongly across the summary description of the Plan.
- The three areas are currently very high-level and will benefit from being developed in more detail, e.g. where does influencing/managing demand fit into the net-zero priority?
- Resilience of transport systems is an important area that could be captured somewhere within the R&D priorities, including resilience to climate change and other significant events that may be largely outside our control.
- The SAC congratulated the team for commencing this important work and developing the Plan based on a vision for desired outcomes rather than merely activities.
- As part of next steps for the work, it is very important to define metrics to measure future progress against the Science Plan objectives; doing this well is challenging. Metrics could also help understand where best to invest to deliver the Plan's priorities.

4.4 The SAC was asked for their continued engagement (including between meetings) as the plan is developed over the next few months, to help shape it and embed it in DfT's culture. It was proposed that, in future, the SAC could regularly (e.g. annually) review progress in implementing the Science Plan.

5. Evidence informing policy on reducing car and van emissions

5.1 An AOB item was raised on the evidence informing policy to reduce emissions from cars and vans:

- It was noted that the Government have recently announced their intention (subject to consultation) to bring forward the end-date for sales of new internal combustion engine (ICE) cars and vans (including hybrids) to 2035 or earlier. Some stakeholders have concerns about the evidence around this proposal.
- The Institution of Mechanical Engineers have recently published a report titled Accelerating Road Transport Decarbonisation – A Complementary Approach Using Sustainable and Low Carbon Fuels. It was noted that this report is supportive of a continued role for ICE vehicles with sustainable, lower carbon fuels including E10 fuels containing 10% sustainably produced bioethanol. The report also stressed the importance of full lifecycle analysis (LCA) of vehicle emissions and concluded that these total emissions will very soon be the same for hybrids as fully electric vehicles. The SAC endorsed the importance of LCA to inform policy decisions within DfT.

- The SAC advised that current Euro 6 and 7 emissions standards for new ICE vehicles are such that their air quality impacts are very low. Given this and LCA considerations, all the evidence needs to be carefully considered to determine the best policy route forward.

6. Potential future deep dive topics

6.1 The following potential topics for future SAC deep-dives were discussed:

- The principle theme discussed was transport decarbonisation and aspects of delivering this, including scrutinizing the high expectations on electrification as part of this. Under this umbrella, the following potential sub-topics were identified: battery performance and supply; electricity generation and distribution requirements for transport; embedded carbon and lifecycle considerations; metrics around carbon, including carbon pricing/valuation (this could be suitable for a joint meeting with DfT's Joint Analysis Development Panel). On anything related to decarbonisation it is important to join up thinking across Government to avoid exporting carbon emissions from transport to other sectors and to identify competition for resources.
- Resilience of transport systems could be another 'umbrella' topic with potential for sub-topics beneath it, including resilience to climate change. It was noted that the Natural Environment Research Council have a climate resilience programme, and that DfT are scoping a new transport resilience science and research programme.
- The role of science in helping to plan, forecast (timescales and budget) and procure major infrastructure projects. This could include learnings from the private sector. Previous engagement of some SAC members with DfT's Transport Infrastructure Efficiency Strategy Programme was noted, and further input from the SAC or a SAC subgroup may be valuable in future. A DfT-commissioned report is currently being produced on how the Department procures major infrastructure projects, and the Secretariat will circulate this to the SAC when it is available (**Action 20-03/6**).
- Regional transport systems – considering how such systems around provincial cities and into rural areas can best function in holistic way. Part of this could be the use of digital technologies and Artificial Intelligence.
- In general, Artificial Intelligence was felt to be more of a cross-cutting theme, contributing to enabling different policy objectives, rather than a specific topic for a deep-dive itself.
- Maritime technology, including autonomous systems, which will be raised under item 8.

7. Pre-discussion of afternoon deep-dive on Influencing travel choices, behaviours and demand

7.1 The CSA provided further commentary to the background paper framing the afternoon discussion. The discussion was intended to focus on how influencing choices and demand can support transport decarbonisation particularly, but with awareness of impacts on other policy objectives such as improved air quality. The SAC were asked to consider opportunities provided by new technology and digital connectivity, possible unintended consequences of influencing choices, and implications for "levelling-up" across UK regions and societal groups.

7.2 The following initial SAC views were raised:

- Travel behaviour is strongly influenced by infrastructure and social relationships.
- There may be some low-hanging fruit for voluntary behaviour change from drivers, but this asks for a lifestyle change because public transport doesn't replicate the experience and freedom of a private car.
- "Nudges" are about providing people with helpful choice architectures, but such approaches alone may have limited impact without regulation and pricing measures.
- A move towards more personalised transport services could increase road traffic, including from miles driven by ride-hailing services between customers (so called 'dead-heading' miles). This could be mitigated by ride-sharing but reports from the US suggest this hasn't really taken-off there.
- This is not just about influencing users, but also transport providers, e.g. to align different services for joined-up journeys.

8. Update on maritime emissions following the December 2018 SAC deep-dive

8.1 An update was given on DfT's work on reducing maritime emissions, following the SAC discussion on that topic in December 2018. As agreed at previous SAC meetings, it is planned that SAC deep-dive topics be revisited after around one year to help the SAC to understand the impact of their advice and how future advice can be made most valuable. A summary was given of the Clean Maritime Plan (CMP) published in July 2019, and progress against it.

8.2 DfT have plans to establish a maritime equivalent of the Office for Low Emission Vehicles, focusing on supporting development and uptake of clean shipping.

8.3 DfT have established a Clean Maritime Council consisting of key industry, academia and government stakeholders to advise on the development and implementation of the CMP.

8.4 The SAC previously advised that policy teams make use of synergies between technology for clean maritime and for reducing emissions from other transport modes and economic sectors, including the possible value of wind energy to generate clean shipping fuels. DfT are taking this approach in studying potential locations for UK zero-emission shipping clusters, involving demonstrator projects for hydrogen/ammonia, and through a proposal under development concerning use of offshore wind power.

8.5 The SAC also previously advised considering the need to move away from 'technology-neutral policies' to provide greater market certainty on particular technologies/fuels. DfT are still following a technology-neutral approach for now, but some support to specific fuels may feature in a consultation this summer on using the existing Renewable Transport Fuel Obligation to encourage uptake of low carbon shipping fuels.

8.6 Of the SAC's advice, the suggestion to consider opportunities offered by coastal and short-sea shipping to reduce road freight has been acted on least. This was considered in a report produced alongside the CMP but did not receive a strong endorsement. It may be revisited as part of DfT's developing Future of UK Freight strategy work.

8.7 The SAC noted that both safety and NOx emissions remain significant issues for ammonia as a maritime fuel, and that removing NOx from exhaust gases must be economically viable. A possible SAC deep-dive on safety of ammonia, and maybe other novel fuels, was suggested.

8.8 The UK are leading discussions within the International Maritime Organisation towards a globally-agreed approach to lifecycle assessment of emissions associated with alternative fuels. This does not generally consider embedded carbon in shipping and port infrastructure, however.

8.9 The SAC's previous advice put more emphasis than others have on the potential role of biofuels in maritime. The Committee on Climate Change has advised DfT that whilst biofuels are technically feasible in shipping, they are not likely to be cost-effective from a whole-economy perspective given other competing uses for this resource. Letter: International aviation and shipping and net zero.

8.10 The SAC was given a brief description of DfT's activity on autonomous maritime technology, where the UK has an opportunity to be world-leading in technology innovation and standards development. The impact of new maritime technology, including autonomy, may be a subject the SAC could investigate further in future.

Action Log

No.	Action	Owner
1	Commence an advertised recruitment process for up to four new members	SAC Secretariat
2	Circulate to members a recent letter from the Council for Science and Technology on joining-up across government on decarbonisation	SAC Secretariat
3	Develop contingency plans for the June SAC meeting in case the response to COVID-19 prevents a physical meeting	SAC Secretariat
4	Provide comments on draft position paper on AVs and human factors	Sarah Sharples
5	Incorporate agreed changes to draft position paper on AVs and human factors, and recirculate to members for approval	SAC Secretariat
6	Circulate to members the report on how DfT procures large infrastructure projects	SAC Secretariat

9. Influencing travel choices, behaviours and demand deep-dive

9.1 The Chair welcomed all attendees and gave a brief overview of the SAC and the purpose and format of the afternoon. The objective of the session was to identify key opportunities and further R&D required for encouraging sustainable travel choices in the 2020s and 2030s, particularly as a contributor to transport decarbonisation. The Chair highlighted the specific questions (see 9.6) on this theme contained in the background paper which was circulated to all attendees ahead of the meeting.

9.2 The policy context to the discussion was summarised. The Government's 2050 net-zero ambition is theoretically achievable through technology alone, but such an approach is unlikely to get us there by the optimum or most economical route, or deliver the changes to our transport that would benefit us now. DfT's work on the

Transport Decarbonisation Plan, to be published later in the year, will include consideration of behaviour change and influencing travel choices, and it was on this topic that the SAC's advice was sought.

9.3 Prof Susan Grant-Muller, University of Leeds, presented on "Opportunities for sustainable travel choices: the role of behaviour change, incentives, new data and new modes," covering opportunities and mechanisms for changing transport choices, and the evidence for their effectiveness. Her presentation included the following points:

- We need to ensure we focus on what works; there are many well-researched models to understand behaviour change and the obstacles to it.
- Efforts to encourage more sustainable transport choices must be accompanied by high-quality public transport options to be effective.
- Micromobility options, such as electric scooters and electric bikes, present some new opportunities. Data from one of Prof Grant-Muller's research collaborations shows that 12% of e-scooter journeys are chosen as a substitute for car journeys, which is where the benefits could lie. More understanding is needed around who does/would choose micromobility, and what factors influence and could further encourage those choices.
- Another opportunity are schemes offering positive incentives for sustainable travel choices. Such schemes are now enabled by 'track and trace' technology and new business models for the provision of incentives and use of the data. Incentives can range from personalised information on journey impacts (e.g. environmental, personal and community health) and costs, to gamification approaches, through to redeemable rewards with monetary value. Schemes can be personalised and tailored to the preferences and needs of individuals or groups (e.g. students). Prof Grant-Muller summarised several schemes/projects that had delivered gains of between 5%-30% in increasing sustainable travel. However, costs and benefits of schemes can vary significantly, and often they do not present a persuasive business case/model to commercial operators, which is a challenge.
- Tradeable travel credit schemes are another potentially effective approach. Such schemes represent a mixture of incentives and disincentive measures, and many scheme designs have been considered. Individuals are assigned an initial set of credits, e.g. a personal allowance for kilometres travelled in sole-occupancy, conventionally fuelled cars. Extra credits may be purchased and unused credits sold. Initial allowances could be tailored to people's level of need, to support equity. Similar to incentive schemes, these can be much more readily implemented with modern technology for location tracking and data-handling, although there would still be an administrative burden. Careful design would be needed to mitigate gaming of the system and unintended consequences, and the public acceptability of such an approach is yet to be established.

9.4 Graham Grant, Newcastle City Council, presented on the local authority perspective on influencing sustainable travel, and the challenges of delivering more sustainable transport within Newcastle:

- Newcastle is aiming to be net-zero carbon by 2030. 30% of the city's total emissions come from transport and 20% from cars. Newcastle achieved a reduction in yearly transport emissions of 82 ktCO2 between 2005 and 2017, but achieving net-zero will require saving a further 400 ktCO2 per year from transport, needing huge changes.

- Decisions taken in the 1970s and 1980s still have a massive influence today on the physical form of Newcastle and other cities, and how people travel around them. Other cities, e.g. Amsterdam, allocated more space to walking and cycling, and it still shows.
- In Mr Grant's view the deregulation of bus services in Newcastle in 1985 undermined integration of public transport services; use of the Tyne and Wear Metro rapidly reduced by around a quarter and has not recovered since.
- Newcastle City Council's plans for more sustainable travel include installing priority bus lanes on the Tyne Bridge and thereby reducing its vehicle capacity. Reallocating road-space to encourage more sustainable travel is always challenging for councils due to public and stakeholder concerns and opposition. Also, major development sites in the city are still underpinned by a financial case linked to parking provision, which goes against a reduction in car use.
- Promoting changes requires targeted communications. For example, in the Netherlands they use ANPR data to identify those who will be affected by transport changes and write to them to make the case.
- Substantial behaviour change may require asking people to do without a car, as it can cost a lot for people to own a car and still choose to use public transport. It was considered important for public transport options to provide an excellent service from day-one or people will be discouraged from switching. Encouragingly, however, evidence shows that young people – particularly in urban areas – do want to travel more sustainably, and that they are learning to drive later and driving less.
- Mr Grant suggested that the current approach to delivery of public and sustainable transport is not working well enough in cities outside of London. He considered that we already know what works for transport: long-term investment and effective regulation. He pointed to the House of Commons Transport Select Committee which has consistently said that cities like Newcastle need to be given more powers to deliver transport policy, accompanied by longer-term funding certainty.
- Mr Grant would welcome further opportunities to trial innovative approaches for sustainable travel in Newcastle.

9.5 Ali Clabburn, Liftshare, presented on "Decarbonising the commute via data and sharing," covering Liftshare's experiences delivering car-sharing schemes for commuters:

- Mr Clabburn cited some statistics: currently around 85% of those commuting by car travel alone, with the average vehicle occupancy for commuting just 1.2 people. This results in 36 million empty car seats in the UK every rush hour. These empty car seats represent a latent capacity on our road network, and increasing car sharing would directly translate to fewer vehicle journeys without increasing demand on other modes.
- It was claimed that Liftshare's members collectively save 320 million car-miles and £26m in travel costs a year, which is a 40% increase from the previous year and ten-times the impact of 5 years ago. Liftshare have an ambition to continue increasing these figures by 40% each year, to deliver a 10% saving in total UK commuting miles by 2030.
- Liftshare's research has shown that cost savings are the biggest motivator for car-sharing, while employers giving preferential access to workplace parking is generally the most effective additional incentive to encourage uptake. Employers find that schemes can help them manage parking demand, and recruit and retain staff.

Several examples were provided of employer schemes where around 40% of staff now car-share.

- There are currently no public policy measures aimed specifically at encouraging car-sharing. Car-sharing is suitable for many more journeys than public transport or active travel. Mr Clabburn believed we should focus on reducing single occupancy car use, rather than car use more generally; that policy and funding has focussed on economical vehicles and not economical behaviours. He suggested that the government could set a realistic target of increasing the proportion of car commuters who car-share to 25% by 2025, from its current level of below 20%. In his view, car-sharing could also be a key part of government's approach to addressing poor air quality.
- A key route to furthering uptake is through employers. Currently, emissions from employee commuting is not a mandatory element of the public emissions reporting requirements on large companies. Mr Clabburn believed making it so would motivate more employers to address these emissions, including through employee car-sharing. Tax or financial incentives could also be offered to employers delivering sustainable employee travel.
- More generally, he suggested that Government and local authorities could consider options to encourage car-sharing or discourage sole-occupancy car use, with measures around preferential parking or road access.
- Future developments risk counteracting efforts to increase car occupancy. Electric cars have lower running costs than conventional vehicles, which may encourage more sole occupancy use. Also, driverless cars may reduce parking demand but increase traffic unless ride-sharing is a major part of their use.
- Mr Clabburn believed Government should fund car/lift-sharing demonstration projects/towns, possibly under the Future Transport Zones initiative.

9.6 All attendees were invited to discuss what they had heard in the presentations, and to consider the following questions:

- Considering Future of Transport innovation and the systems, tools and technologies that could be brought to bear, what are the key opportunities and mechanisms for influencing transport choices and demand in the 2020s-30s, especially to support decarbonisation?
- What evidence is there on the effectiveness of such mechanisms, and what are the key evidence gaps that require further study?
- How far can we expect voluntary choices to get us toward the behavioural changes needed for decarbonisation, and how much will stronger interventions be necessary?
- What are the potential wider system-level challenges this could bring, including affecting capacity or availability of routes on other modes and infrastructure?

9.7 The following range of independent views were contributed by SAC members and other invited attendees:

- We have not unlocked radical behaviour change before and making a step-change will be very challenging. Even if you give people a 'better' travel option, people stick with what is convenient and satisfactory or sufficient, rather than choosing what is objectively best.
- There is evidence on 'what works' for behaviour change, from transport and other relevant scenarios, but much less on what works quickly and at scale. Some

examples of genuine widespread changes (such as seatbelt use) required persistent effort over a long time period.

- Given the importance and scale of the challenge, it was suggested that actions to discourage some transport choices need to be considered alongside interventions encouraging others. Some attendees felt that the real change needed is to reduce car use, and achieving this at the scale required may require disincentives, including financial, not only incentives.
- It was suggested that the biggest influence on car use is car ownership, given the convenience and current economics once someone had committed to owning or leasing; there is currently little focus on trying to affect this, and enabling more people to live without a private car.
- The issue was raised of how government will deal with the reduction in fuel tax revenue as people move to electric vehicles, and it was thought that the approach to this would have a big impact on how people travel.
- More road user charging was thought to be one option, possibly with some dependence on car occupancy. Few local authorities have used the available legislation to implement road charging schemes, because of the political challenges of doing so. The language of “congestion/road user charging” is perceived very negatively by many. Talking instead about “polluter pays” principles was thought to be likely to be received much more positively. The technology now exists to charge for road use in very dynamic and flexible ways to affect demand.
- Several operators were beginning to offer demand-responsive bus services, including services enabled by ViaVan who were represented at the meeting. ViaVan believed they can persuade users to choose on-demand buses over their cars – and potentially give up their cars – if pick-up waiting times are no more than 15 minutes. ViaVan also provide dynamic road tolling software, including launching a scheme in Israel which will operate together with positive incentives for sustainable choices.
- Real-time journey-planner apps do and can influence choices to some extent, and new data streams on the costs and impacts of actual trips, provided pre- and post-trip, can play a valuable role.
- Streets have generally been designed to maximise car throughput, although exceptions are increasing. It was suggested that it could be possible to support sustainable travel by designing the road environment for public transport and active travel, giving them priority.
- The type of data underpinning the operations of Liftshare’s and demand-responsive buses was considered to be underutilised by public transport operators. Big employers and transport operators could cooperate more and use data to deliver sustainable travel to potential customers. However, many bus operators may have a fixed mentality about their market, and not view car users as potential new customers or have sufficient incentive to try and compete with private car use.
- Incoming regulations (under provisions of the Bus Services Act 2017) will require bus operators in England to share service and fare data in open formats. This has the potential to support more integrated and attractive public transport by providing easy access to real-time information on bus arrivals and enabling complementary third-party products and services, such as journey planning apps or connecting transport services. It was also suggested that bus operators could also be required to share valuable data with local authorities (LAs), such as who is using their services.
- Another idea was for more onus to be placed on schools for how pupils travel and reducing the number of car drop-offs. This would have strong benefits in terms of carbon and air quality emissions, and pupils' health if replaced by active travel.

- It was suggested that more government funding could be directed towards influencing sustainable choices and demand, rather than overly focussing on technology changes.
- It was noted that the National Infrastructure Commission and House of Comments Transport Select Committee pointed to the fact that the top ask from LAs to help deliver sustainable travel was a long-term funding settlement. The current system of bidding for funding was considered to place LAs in competition with each other, potentially discouraging valuable collaboration. Continuation of long-term funding at agreed levels could still be made dependent on performance against clear metrics for increased sustainable travel, reduced car use, etc. These could take account of local circumstances and be carefully set to avoid potential unintended consequences. It was agreed that it remains vital that transport can be accessed by all, and that LAs deliver a holistic response across transport, health and other policy areas.
- Some LAs would also like more enforcement powers under the Traffic Management Act to help them deliver transport policy.
- It was suggested that, to make the required progress on sustainability, there should be a focus on delivering large-scale changes soon, rather than small-scale demonstrator projects or calling for more evidence. Sufficient evidence was considered to already exist on what works to effect change, especially on price and convenience.
- There is now increased public awareness of environmental impacts and appetite for change, and this presents opportunities.
- More large companies are making carbon commitments that include all emissions generated from their upstream supply chain and downstream product lifecycle impacts (so-called scope 3 emissions). This mindset is really important to prevent exporting the issue between sectors, and each part of government ought to have this mentality. The earlier suggestion that employers should report emissions from employee commuting aligns with this approach.
- Tradeable travel credits (or combined transport and household energy credits) were considered to be an interesting approach which we have only recently had the technology to deliver. It was suggested that these could really affect people's choices while at the same time helping to address transport equity and social inclusion.
- It was suggested that it would be beneficial for Government's approach to addressing air quality to be widened to think more holistically about air quality and carbon together.
- The increase in purchases of sports utility vehicles (SUVs) counteracts efforts to reduce emissions. It was suggested that this trend toward larger vehicles could be addressed through disincentives, social pressure, or other means.
- The right skills and knowledge are needed to deliver change, including the right focus and expertise within LAs, and data skills within transport companies/operators.
- It was suggested that the policy focus should be on people's fundamental needs and benefitting society as a whole. We must not be seduced by new transport technologies and business models that have a detrimental impact overall. Changes should be pitched in terms of the positive impacts and opportunities.
- Change is required in the behaviour of regulators and policymakers around these issues, not just transport users.

9.8 The following points were raised specifically in response to the second question listed in 9.6, concerning evidence/evidence gaps on effective approaches:

- As noted previously, there is less evidence on how to effect large-scale behaviour change quickly, as is needed to address climate change.
- There is a specific evidence gap around more sustainable, alternative transport options for longer journeys of over 50 miles, which are a big contributor to total mileage.
- The immediate evidence gap is how COVID-19 will now impact these issues, and research and thinking into this ought to be a priority. Among the possible impacts are a significant long-term increase in home/remote-working, as well as changing how companies and academics collaborate internationally, with more virtual interaction and less travel.

9.9 The following points were raised specifically in response to the third question listed in 9.6, on how much voluntary/discretionary change can be expected:

- It should be recognised that a level of individual change exists within the system already, with many people changing their behaviour at any time, rather than there being an insurmountable collective inertia. Habits are perhaps not as entrenched as we often believe and maybe we can leverage these changes to achieve greater change across the system.
- Rather than a blanket approach, appeals to people to make discretionary changes/choices can be focussed on moments of significant life-changes (new job, house, family responsibilities etc) to maximise their impact. Marketing of new travel options/facilities can also be carefully targeted. Information and data to influence choices should not just be available to the tech-savvy though apps, but also be promoted through traditional media.
- The image of different transport options is an important factor influencing their use. Buses still largely have a poor image, which could be addressed. DfT are directing a lot of funding to buses, but it is really important what those buses look like and what passenger experience they offer. In comparison, the perception of cycling has changed markedly in recent years towards being a more desirable means of transport.
- 'Voluntary' change depends on people trusting the messages about the need for change and trusting that others will also do their part. Pleading to personal altruism will not work if policies give mixed signals, or people are told that it relies on everyone else too. Given this, the impact of entirely voluntary changes may really be quite small.

9.10 The following points were raised specifically in response to the fourth question listed in 9.6, concerning challenges and considerations across the whole transport system:

- Effective integration of sustainable transport options is key to uptake (as supported by the earlier example of bus deregulation in Newcastle) and may not be optimally delivered by the market.
- Allocation of street space to different modes is an important consideration and, with demand for space high, difficult choices have to be made.

9.11 After the departure of external attendees, the SAC members, supported by DfT attendees, considered their reflections and conclusions from the session. The following points were discussed:

- New sharing and on-demand services enabled by technology can be an important part of the solution.
- It was noted that Liftshare have received a DfT Transport Technology Research and Innovation Grant (TRIG) for a scheme joining-up car-sharing and parking access at the ARM company HQ near Cambridge.
- More traditional public transport services have also improved substantially over time, but the public perception of them has not kept up in all cases, and this could be addressed. The incoming regulations requiring bus operators to share their service data should have a positive impact in encouraging bus use.
- New data streams do provide new opportunities that require supporting governance and regulation around data use. Getting benefit from data depends not just on the existence and availability of the data but also motivation, skill and effective visualisation/presentation.
- The delivery of infrastructure changes to support more sustainable transport requires the political will from policymakers in government and local authorities. There can be significant public opposition to changes affecting people's transport choices, and there is a risk of a wider backlash if we overestimate public appetite for change to address the climate crisis. It would be valuable to capture success stories of change to show people positive impacts.
- There was some support reiterated for the suggestion that LA funding for delivering sustainable travel could be made dependent on performance against relevant metrics.
- Placing more accountability on employers for sustainable employee commuting, and on school authorities for sustainable pupil travel, would be significant changes that could make a real impact.
- A key aspect of behaviour change is increasing public support for the very significant policy changes that could be necessary to deliver our climate commitments. Young people can be a source of support for the type of significant changes that are required in transport, and their views can be actively sought. It was noted that BEIS have a young people's focus group on achieving net-zero.
- Government needs a clear appreciation of the different scales of change that different interventions can reasonably be expected to deliver. The evidence for this largely exists and needs to be clearly summarised for policymakers. There also is not time for lots more research when change is needed now; a better approach may be to make changes at scale immediately and build in effective evaluation programmes. Any demonstrator projects would be most valuable if at large scale or very readily scalable, with a focus on real-world outcomes.
- The House of Lords Science and Technology Select Committee report on Behaviour Change from 2011 included consideration of interventions to reduce car usage in towns and cities, and its conclusions remain relevant. 'Nudges' can provide a limited part of the solution if the right 'choice architecture' is put in place.
- Mobility credits are an interesting approach that could be considered further, and it was noted that such a scheme is already happening in Coventry.
- There is a benefit of learning from international examples This was not addressed sufficiently in the discussion. European Green Deal cities could provide good exemplars.

Annex D: Position statement on influencing travel choices, behaviours and demand

The conclusions and advice described in this position statement are the opinion of the SAC at the time it was finalised in June 2020. They do not represent the positions of DfT and DfT ministers. These positions may also change over time as new technology, policy, and societal factors emerge.

Introduction

The Department for Transport's Science Advisory Council (SAC) met on 4 March 2020 to discuss the opportunities, and required research and innovation, around influencing sustainable travel choices and demand, particularly as a contributor to transport decarbonisation. This paper summarises that discussion and the SAC's conclusions. (Note that these pre-date and do not reflect the major impacts of the COVID-19 pandemic on travel and the economy, and pre-date the publication of the Transport Decarbonisation Plan.)

Choices affecting transport demand relate to both the movement of goods and people, and to all modes including maritime and aviation. However, in order to focus the discussion, the SAC was asked to consider only the movement of people on land journeys.

The SAC was specifically invited to consider the following questions:

1. Considering Future of Transport innovation and the systems, tools and technologies that could be brought to bear, what are the key opportunities and mechanisms for influencing transport choices and demand in the 2020s-30s, especially to support decarbonisation?

2. What evidence is there on the effectiveness of such mechanisms, and what are the key evidence gaps that require further study?

3. How far can we expect voluntary choices to get us toward the behavioural changes needed for decarbonisation, and how much will stronger interventions be necessary?

4. What are the potential wider system-level challenges this could bring, including affecting capacity or availability of routes on other modes and infrastructure?

Several subject-matter experts from academia and industry joined the meeting to provide their views and contribute to the discussion.

Background

Transport is an essential enabler for people to live their lives, providing access to services, education, employment, social interactions and leisure activities. DfT is committed to connecting people and places, delivering the transport system people need now and being ambitious for the transport system of the future. However, high demand for transport currently has several negative impacts, including greenhouse gas (GHG) emissions, poor air quality and congestion or overcrowding at peak times on all modes. In the SAC's view, these negative outcomes are unlikely to be addressed purely through either technology change or capital investment aimed at increasing capacity; interventions to influence travel choices, behaviours and demand were thought to have an important role to play.

The transport sector is the largest contributor to UK greenhouse gas emissions, contributing 28% of the total in 2018, with around 21% from road transport alone. Over the last 30 years, both have remained fairly stable in terms of absolute emissions, while other sectors (notably energy supply) have reduced emissions. While the SAC note that the UK's Committee on Climate Change (CCC) considers it feasible to achieve net-zero carbon emissions from UK domestic transport by 2050 through technology alone (principally the move to zero-emission vehicles), the SAC consider this unlikely to be optimal in terms of risk and economic cost. Furthermore, modelling suggests that meeting Carbon Budgets 4, 5 and 6, together covering 2023-2037, will require significant modal shift (e.g. modelling for the Government's 2017 Clean Growth Strategy included modal shift from cars to cycling/walking contributing 25% of the carbon saving required from transport to meet Carbon Budget 5).

Nor will a purely technological approach solve congestion or overcrowding, or fully or sufficiently quickly address air pollution. Road transport emissions are one of the main causes of poor air quality in cities, which is the largest environmental risk to public health. As well as being a serious immediate problem, this will not be entirely resolved by the planned transition to zero (tailpipe)-emission vehicles, as particulate-matter pollution from brake and tyre wear will remain an issue.

The transport use that generates these impacts has grown consistently across all modes and, without significant lifestyle changes, is forecast to continue growing. DfT forecasts road traffic to grow by between 17% and 51% by 2050 under a range of plausible scenarios. Rail forecasts also show increasing demand on the network.

Influencing travel choices can affect how and when people travel as well as, potentially, the total pressure on the transport system. All of these changes, to varying extents, have the potential to lessen the negative outcomes of travel and to offer significant co-benefits. Key changes to reduce negative impacts would be a reduction in the use of private cars and a spreading of peak demand on all modes.

The concept of demand management was a key tenet of transport research in the 1990s. With the technology and data services now available, and new mobility models, there may be an opportunity to look again at influencing travel choices around when and how people travel as a key tool to support objectives including transport decarbonisation. Interventions aimed at influencing choices must be informed by high-quality behavioural science to have the best chance of success.

Opportunities for more sustainable travel choices

Active travel and micromobility

Fifty-seven per cent of all car journeys are between one and five miles (although contributing only 15% of total miles driven), suggesting there is scope here to change to more active modes or micromobility options. It is a government ambition to "make cycling and walking the natural choices for shorter journeys, or as part of longer journeys, by 2040", and active modes have significant health benefits for individuals. One focus could be further interventions aimed at enabling and incentivising local authorities (LAs) and schools to deliver increased use of active modes for pupils' journeys to and from school (together with buses and lift-sharing for longer journeys). DfT currently supports sustainable and active travel to schools through the Modeshift STARS Education scheme to assist and recognise excellence in sustainable travel plans, as well as funding school cycle training. There are very strong co-benefits here in improved child health and air quality near schools and reducing car drop-offs can also free parents to make different transport choices for commuting or other purposes. The Department for Education are in the process of revising statutory guidance on home-to-school travel and transport, including obligations on LAs to annually document their strategy to promote sustainable modes of travel for school needs. However, at present this is not accompanied by explicit, significant incentives for successful implementation.

Micromobility modes such as electric bikes (and potentially, in future, the legal use of electric scooters), including under public sharing schemes, also provide new opportunities for replacing car journeys. Further research is required to better understand factors influencing the choice to use these relatively new modes, the characteristics of users/potential users, and approaches to potentially encouraging increased use.

Public and shared transport

Apps and data-sharing have begun to support increased offerings of commercial, on-demand ride-sharing and bus services to meet specific needs for regular or one-off journeys. There is significant further potential to increase and improve data and information sharing between large employers, shopping centres, hospitals, schools (i.e. those generating substantial travel demand) and transport providers to inform better provision of shared travel options. Buses remain the primary form of public transport in most places, but are often not considered an attractive choice, and established bus operators generally don't consider regular car-users as a potential new market. Bus offerings are changing, however, and with support and innovation these barriers might be addressed. Bus attractiveness and utilisation can be supported by delivery of incoming requirements on operators in England (under provisions of the Bus Services Act 2017) to share service and fare data in open formats. This will provide easy access to real-time

information on bus arrivals and support complementary third-party products and services such as journey planning apps or connecting transport services. There would also be benefit in bus operators being required to share with LAs valuable information on who is using their services.

Car-sharing

Sixty-two per cent of car journeys in England are by drivers alone in their vehicles, and the average car occupancy for all journeys is just 1.55 Empty car seats represent a latent capacity on our road network, and increased car-sharing would directly translate to fewer vehicle journeys without increasing demand on other modes. Private car-sharing is most viable and impactful for commuting, where there is high regularity and commonality in destinations and travel times, which accounts for around 25% of the total distance travelled by car in the UK and around 20% of the total distance from all motor vehicles. Currently the lone-driver rate for commuting is 87% and the average occupancy just 1.2. However, many large employers have started to offer and incentivise employee car-share schemes. Sharers approximately halve their travel costs and can be offered further incentives; for example, preferential access to workplace parking has been found to be particularly effective in encouraging uptake. Employers have also found that schemes can help them recruit and retain staff, and manage parking demand. The SAC heard evidence from Liftshare, one of the UK's largest car-sharing systems providers, who currently work with 700 employers as well as offering a free platform to the public. They calculated that their users collectively save 320 million car-miles a year, and believe it is possible to continue increasing this figure by 40% each year, to deliver a 10% saving in total UK commuting miles by 2030.

There are currently no government policy measures aimed specifically at increasing lift-sharing (although there are regulations pertaining to workplace parking that are designed to encourage reduced car use). Government and LAs could consider options to provide preferential route and/or parking access as incentives, similar to those from employers. Government could also consider funding car/lift-sharing 'demonstration towns' (possibly under the Future Transport Zones initiative) and making car/lift sharing a stronger focus of action on air quality.

There also needs to be a focus on shared mobility to mitigate the potential for other trends to increase private vehicle mileage: electric vehicles have much lower running costs than conventional vehicles, which could encourage increased personal use; drivers for ride-hailing apps can contribute disproportionately to congestion in cities due to miles driven between customers; and, in the future, autonomous vehicles may travel empty.

Approaches to influencing sustainable choices and demand

Travel demand is strongly dependent on land-use planning and development, determining the journeys people require and the practicality of different modes. Encouraging greater use of public/shared and cleaner modes also requires designing and engineering streetscapes to give space and priority to these modes, rather than the traditional focus of maximising car throughput. More broadly, effective levers of change often exist at a local level, and while DfT can set a national framework for change, local factors and decisions will be key. In recent years LAs have had to bid into short-term government competitions

to secure central government funding for investment in transport infrastructure and sustainable transport projects, including the Transforming Cities Fund (2018-2023) and the Local Sustainable Transport Fund (during 2011-2015). As recommended by the National Infrastructure Commission, more certain, longer-term funding settlements would likely better support LAs to successfully plan, develop and deliver sustainable and more innovative local transport. In line with this, the March 2020 Budget provided eight Mayoral Combined Authorities with five-year funding settlements for local transport infrastructure investment from 2022-23. This principle might also be usefully applied to other LAs and sustainable transport activities. To drive successful delivery, continuation of longer-term funding settlements at agreed levels could be made dependent on performance against clear metrics for increased sustainable travel, reduced car use, etc., though still taking account of local circumstances. Funding models that do not place LAs in competition with each other may also foster greater collaboration, to the benefit of all.

Significant evidence and models already exist on what is and is not likely to be effective in influencing travel choices – although it is recognised both that there is less evidence on what works at large-scale and at speed, and that circumstances and public attitudes are changing. Firstly, it is essential that alternative choices and transport modes are accessible and provide a good service so that they are practical choices. Travel choices are highly habitual, and attempts to inform and influence individual travel choices will be most effective if targeted to specific times of change in people's lives, such as having a new home, job or family changes, as well as to specific demographics.[2] Communications are likely to be most effective if their content and language focuses on the positive co-benefits of more sustainable travel choices, such as cost-savings, improved health, or more usable time. While they can have a role, it should be recognised that simply providing information, appealing to people's altruism or providing 'nudges' will likely be insufficient alone to address the challenge of decarbonisation in particular, which requires large-scale behavioural and societal changes. The conclusions of the 2011 Behaviour Change report by the House of Lords Science and Technology Committee remain valid and informative in relation to this.

Schemes offering positive incentives for sustainable travel are now enabled by location tracking technology and new business models for the provision of incentives and/or use of the data. Data obtained on people's travel can provide valuable insights to service providers, LAs, and others. Incentives can vary from information on journey impacts (e.g. environmental, personal and community health) and costs, to gamification approaches, through to redeemable rewards with monetary value. In all cases the approach can be tailored and personalised to the preferences and needs of individuals or certain groups (e.g. students). As an example, the EU Horizon 2020 demonstrator project EMPOWER recently operated in Milton Keynes and three other European cities, achieving reductions of 10-27% in use of conventionally fuelled vehicles (CFVs) among those taking part.

Tradeable travel credits (or carbon credits for travel and household energy use) are another option that have been considered at a theoretical level with a variety of designs, and might provide an effective method of achieving behaviour change. These provide a market mechanism mixing 'carrots and sticks,' with individuals assigned initial allowances, for example for private CFV kilometres, and able to buy additional credits or sell any

[2] The COVID-19 situation has subsequently been widely identified as a "moment of change" that could be used to instil new, sustainable habits, but this will require DfT to maintain early awareness of changing public responses.

unused. Initial allowances could be tailored to people's level of need, to support equity. Similar to incentives schemes, these can be much more readily implemented with modern technology for location tracking and data-handling, although there would still be an administrative burden. Careful design would also be needed to mitigate gaming of the system and unintended consequences, and the public acceptability of such an approach is yet to be established.

There is considerable evidence to show that one of the most effective levers to influence transport use remains price. Modern technology also makes possible new direct pricing mechanisms, particularly in relation to private vehicle road-use. Unlike some other modes (e.g. trains) the cost of driving has never varied with time-of-day or day-of-the-week to reflect and moderate demand at peak times, but this could be achieved with modern technology, including on a dynamic basis responding to real-time information. A "polluter pays" principle and language is likely to be more effective if governments/authorities wish to encourage public consent for such approaches, although they remain politically challenging. Any interventions involving pricing or financial measures, or in other ways seeking to manage travel, must carefully support equity in people's access to transport and its benefits.

To be most effective, approaches could focus not only on individual travellers, but also organisations generating significant travel demand, such as large employers, shopping centres and schools. In addition to the lift-sharing schemes mentioned above, some employers also offer charter bus services or cycling schemes for employees. More generally, many companies have recently announced voluntary net-zero GHG commitments, with some including within their scope the emissions from their full upstream and downstream supply-chains. Aligning with such moves, an effective approach may be for government to focus on engaging employers to further encourage sustainable commuting and business travel. Government could consider the case for motivating more employer action by requiring larger companies to publicly report emissions from employees' commuting and business travel (currently this is an optional element of the GHG emissions reporting requirements for larger companies in the UK). Tax or financial incentives for employers supporting sustainable travel could also be considered.

SAC advice to the Department

The SAC recognise that data and connectivity provide both some new transport options and new opportunities for interventions encouraging sustainable travel choices. However, the challenge of achieving behaviour change with the scale and speed necessary is very significant. Given the imperative to act quickly, the SAC advises that DfT focus on real-world implementation and impact soon, informed by existing early-stage research and accompanied by effective evaluation programmes.

1. The SAC advises that DfT conduct/commission a review of existing evidence on what is and is not likely to be effective in influencing travel choices, and use this to inform interventions soon and at large scale. The review would benefit from a wide scope, reflecting the need for joined-up programmes of interventions to achieve behaviour change. The SAC note that DfT have an evidence review underway on the impact of interventions to encourage switching from cars to more sustainable modes of transport, which will partially address the first aspect.

2. Applying strategic roadmapping methodologies with stakeholders could be used to develop exemplar case studies for specific cities and regions, identifying suitable approaches and prioritising actions.

3. Demonstrator projects are likely to be most valuable if they: target clear outcomes and integrate effective evaluation programmes; reflect local situations and needs, but also demonstrate further scalability and transferability; are at whole-city or regional scale, involve already mature technologies and be supported by a full range of stakeholders. The cross-sector Transport Research and Innovation Board (TRIB) could play a role in steering and coordinating such initiatives at a national level.

4. The SAC advises that, while it can have a valuable role, seeking to influence individual choices through providing information and encouragement alone is likely to be insufficient for a challenge of this scale requiring large behavioural and societal changes. The SAC advises that stronger policy levers, including incentives, price, and regulation be considered as part of an integrated approach for effective action. Good communication is critical to successful implementation, and a "polluter pays" principle and language is likely to be more successful if government and other authorities wish to encourage public consent for such approaches.

5. Rather than focussing only on individual travellers, a more effective approach will be to engage through multiple routes such as employers and schools:

   Government could further consider the case for including employee commuting as an additional element of mandatory GHG reporting for larger companies under the Streamlined Energy and Carbon Reporting requirements.

   Government could consider approaches, with the right support, to increase the incentives and accountability for local authorities (LAs) and schools to deliver sustainable travel for pupils' journeys to and from school.

6. In line with the recommendation of the National Infrastructure Commission, the SAC suggests DfT consider the potential benefits of providing more LAs with more certain long-term funding for sustainable transport infrastructure (including data and digital infrastructure) and innovation. Continuation of full funding could, however, be made dependent on clear metrics for successful reduction of emissions, decreased car use, etc.

Annex E: 8 April 2020 meeting summary – COVID-19

Members of DfT Science Advisory Council took part in a videoconference on 8 April 2020 to provide suggestions and ideas on transport data use, research needs, and future scenarios related to COVID-19 response and recovery. The key points raised are summarised below.

Data gaps and opportunities

- **Evidence on how adherence to lock-down/social distancing measures may erode over time due to 'lockdown fatigue'** – Data could identify predictive indicators of general breaking of social distancing. This could be gathered through smartphone location and internet/search data (e.g. satnav searches for long journeys; increased searches for 'beach' clothes). This has strong privacy considerations but would still be useful at an aggregated level.
- **Data to measure and predict how people will return to transport after travel restrictions and social distancing measures are relaxed** – During this transition there will be very rich data available to understand people's new preference, if government and others are positioned to collect it.
- **Data on wider activities related to transport demand** – Transport is a derived demand – derived from demand for the activities it enables – so it will be important to understand the likely and actual impacts on transport with wider contextual data. With potential for increased home working and online shopping, it will be important to consider data on reduced transport use in conjunction with data on internet and residential energy usage, changes in retail spending, etc, to understand knock-on effects across the whole system.
- **Data on air pollution associated with vehicle emissions** – Collecting the right air quality and traffic data now, and during the lifting of restrictions, could provide valuable improvements in our quantitative understanding and modelling of the contribution of vehicle emissions to air pollution, supporting the best policy decisions.
- **Data communication** – In all cases, data must be communicated clearly, with reference made to chosen baselines, uncertainties/confidence levels, trends, etc, and effective visualisation of data.

Use of transport data collected to support COVID-19 response

- Much of the near-real-time transport data that DfT has collated to inform the COVID-19 response should become a valuable part of DfT's business-as-usual post-pandemic. This will require successfully making the case to external data owners to continue sharing data after the crisis eases.
- DfT must prioritise data that provides actionable information, and understand prior to collection the decisions it will inform, including in response to potential secondary peaks in COVID-19 infections.
- Increased use of data post-pandemic will require public trust and consent. This will require careful communication with the public, with the case for data use made based on the benefits to society as a whole.
- Making data sets freely available to the public and industry will be important to maintaining trust in government data use, and enable third parties to derive further value from them.
- Regional authorities should be encouraged and supported to share and use their transport data effectively to support local needs, including rural economies.
- A national centre for transport data could be established to be responsible for collating increased amounts of transport data, making it available, and upskilling people across the transport sector to use it. Mandating a national centre with these responsibilities would support public confidence that the data was being used appropriately and for the common good. Newcastle University's Urban Observatory was highlighted as an example of what can be achieved in collating transport and related data at a local level.

Wider research needs

- Modelling of air flows and ventilation systems in airports/stations could help better understand the distance people ought to keep apart in these spaces, and how use of space can be managed to minimise virus transmission. When restrictions are eased this could help mitigate a potential second peak of infections and help increase trust/confidence in transport hubs.
- Both quantitative and qualitative research will be important to understand changes to attitudes and behaviours. Measures of sentiment on social media will be informative. New questions could be added to the National Travel Attitudes Study (although noting the value of maintaining question consistency for longitudinal analysis where possible), or other survey vehicles. Qualitative research is also vital to fully understand people's views.
- After restrictions are eased, people may use public transport less due to infection concerns. It will be important to understand:
  what people's concerns are around public transport, and how to allay these concerns and increase trust and confidence in public transport.
  whether this results in increased use of personal vehicles.
  whether it results in increased active travel.
  how to use this change to encourage further active travel, in line with existing government objectives.
- It will be valuable to understand whether and how businesses are changing their expectations around working from home, and how this may impact the scale of business accommodation required.

Post-COVID-19 Futures

- There will be a window of opportunity to embed longer-term change following the pandemic, but it will be short. Government should be planning now to take advantage of this opportunity.
- There may be increased public support for certain approaches, which could be assessed through citizen engagement activities, and this may allow government and others to be more ambitious and progress approaches not possible before the pandemic.
- This could be used to lock-in sustainable travel behaviours and make a step-change in progress towards decarbonisation.
- There could be a longer-term increase in home working and reduction in business travel and commuting peaks, especially into cities, with some associated benefits. Government may wish to encourage this and support it with further enablers such as improved internet infrastructure.
- There may be increased public challenge to DfT and local authorities on improving air quality, as a result of the noticeably cleaner air in some areas during the pandemic response.
- There may be a greater reluctance to use public transport due to concerns about infection and a desire for isolation, security, and independence. This may result in an increase in private car use and ownership, and could hamper efforts to make transport more sustainable. It could severely damage public transport in some regions, especially rural bus networks. There will need to be concerted efforts to address these concerns, and to support the health and safety of transport workers, to get people back on public transport.
- There could be an increased longer-term demand for home deliveries. This may need to be enabled by things like increased/priority access and unloading space in residential areas.
- It may result in further hollowing out of the high-street or an increase in out-of-town shopping centres, resulting in more social isolation and greater reliance on cars.
- There will be huge economic impact on transport overall, as for other sectors. Government will need to provide the right support to the transport sector to retain existence of the transport services we want. DfT should think carefully which transport priorities offer most value to the wider economy in the recovery from COVID-19.
- Aviation will be particularly affected, with economic damage now and longer-term impacts on demand. The speed at which people return to aviation will determine how many companies survive.
- Businesses and universities may move to holding more international meetings and conferences online, with a higher threshold for justifying travel.
- Changes in aviation projections will need to be considered in policy decisions.
- Future freight and logistics needs may be significantly affected by altered behaviours and economic impacts on retail and manufacturing, and should be carefully reassessed.
- Large-scale infrastructure needs may require reassessing in consultation with the National Infrastructure Commission.
- Impacts on transport must be considered alongside related impacts in wider systems, e.g. reduced travel to work could be accompanied by increased residential heating and associated carbon emissions.

Annex F: 10 June 2020 meeting minutes – COVID-19 and DfT Science Plan

DfT Science Advisory Council

10:00–12:00 Wednesday 10 June 2020

Via videoconference

Council Members attending

- Prof Lord Robert Mair (Chair)
- Prof Barry Clarke
- Anna-Marie Greenaway
- Prof Peter Jones
- Prof Ricardo Martinez-Botas
- Prof Nick Pidgeon
- Prof Sarah Sharples
- Dr Dave Smith
- Prof Paul Watson

DfT Attendees

- Prof Phil Blythe, Chief Scientific Adviser
- Dr Siobhan Campbell, Head of Central Research Team
- Private Secretary to the Chief Scientific Adviser
- SAC Secretariat
- Head of Academic and International Engagement, DfT Office for Science
- Head of the Transport Research Innovation Board, DfT Office for Science
- Assistant Private Secretary to the Chief Scientific Adviser
- Science Plan Senior Policy Adviser, DfT Office for Science
- Head of DfT Office for Science

These minutes summarise the range of independent views and opinions expressed during the meeting, without generally attributing these to individual attendees. Individual opinions

may not be the view of the SAC or group of attendees as a whole. Neither individual views nor SAC advice should be taken as representing the positions of DfT and DfT ministers.

1. Review of minutes from March meeting

1.1 The minutes from the March meeting were agreed without any amendments.

2. Review of draft position paper on Influencing travel choices and demand

2.1 This paper follows from the deep-dive on this topic at the March SAC meeting. The following comments were made and changes agreed:

- The paper will need to be caveated to acknowledge the relevance of the significant impacts caused by COVID-19 since the discussion on 4 March.
- When referencing the "moment of change" due to COVID-19, the paper should acknowledge that DfT must maintain early awareness of the changes resulting from COVID, as well as trying to influence them.
- In relation to the scope for change to active and micro-mobility modes, the paper states that 51% of car journeys are under 5 miles. However, the fraction of total vehicle-km that these journeys make up will be considerably lower and this should be noted.
- The paper should recommend applying strategic roadmapping to cities/regions to prioritise actions for influencing travel, and to obtain good case studies. This methodology has a strong academic underpinning. Anna-Marie Greenaway offered to supply some summary lines and references on strategic roadmapping (**Action 20-06/1**).
- The paper may be overly positive on the level of relevant evidence and knowledge about what works to influence choices and demand, and should be clearer on this. The reference to "substantial" evidence should be removed from recommendation 1.
- There is naturally less evidence concerning take-up of newer options, such as micromobility modes. The impact of COVID has affected people's considerations around mode choice, including enhancing opportunities for micromobility options.
- The suggested evidence review in recommendation 1 must have wide scope, reflecting the need for joined-up programmes of interventions to achieve behaviour change (as concluded by the 2011 Behaviour Change report by the House of Lords Science and Technology Committee).
- Given wider evidence, the draft paper may be too positive on the potential role of car sharing, including giving implied priority to this by discussing it first. This should be moderated.
- The paper should make the point that levers for change are often at a local level and, while DfT can set a national framework, local factors and decisions will be key.
- The paper could make a stronger statement about the required balance between encouraging and supporting individual choices, and stronger government interventions.
- Rather than recommendation 2 saying that early-stage research should not be DfT's focus, it should recommend that it is used to inform the real-world implementation.
- The importance of data as part of sustainable transport infrastructure should be mentioned in recommendation 5.

2.2 The Secretariat will revise the paper and recirculate with tracked changes for final approval. (**Action 20-06/2**)

3. Review of draft position paper on Highly Automated Vehicles: Human Factors considerations for accessibility and safety

3.1 This paper follows from the deep-dive on this topic at the November 2019 SAC meeting. The SAC was happy with the changes made to the paper in response to their previous comments at the March Council meeting and by email. The following final changes were agreed:

- Reference was made to current activity around standards for how automated vehicles (AVs) will access and interact with the kerbside. Peter Jones offered to supply some wording on this issue to add to the paper (**Action 20-06/3**).
- The current drafting makes repeated reference to the needs of older people. There is great value, specifically, in keeping older people mobile and able to access healthcare. However, this emphasis should be tempered and the paper's focus kept more on technical issues, since all age groups are important and will have specific challenges.
- The particular meaning of "diverse needs" in the first paragraph could be clarified.
- As also noted in previous discussions, the desirability of AVs beyond their functionality will be an important factor in their development and adoption. Like other products, AVs will need to be affordable, desirable, and sustainable to take off, and some of the technology for fully accessible vehicles will likely develop first in high-end vehicles marketed on their desirability. The paper could still reflect these points more.
- Notwithstanding the preceding point, the statement that "we may be further away from this widespread public appetite for AVs than we are from overcoming the technical challenges in their development" should be amended so as not to downplay the significant technical challenges that remain for widespread deployment.

3.2 The Secretariat will revise the paper and recirculate with tracked changes for final approval. (**Action 20-06/4**)

4. Update on how science is informing the restart of transport

4.1 Phil Blythe briefly updated the SAC on the Department's use of science to inform the return to transport following the COVID lock-down, including the following points:

- DfT are continuing to use new data streams to track levels of transport use to inform planning.
- The Department is reviewing and commissioning evidence on factors affecting COVID transmission on public transport. Academic work on air flows inside vehicles and stations/transport hubs was noted.
- Defra are leading work to understand how the reduction in transport use has impacted air quality, helping to better understand the relationship between the two. A discussion on this topic between interested SAC members, Phil Blythe and the Defra CSA was suggested. Local authorities are keen to work with Defra and DfT to understand how the impacts of COVID could affect the requirements for Clean Air Zones.

- DfT recognises that there are opportunities for change to public transport, including through increased use of micromobility.
- In the longer term, the need to transport more vulnerable, older people in isolation could provide a new use case for automated vehicles.

5. Transport opportunities post-COVID

5.1 Siobhan Campbell introduced the item, referring to the meeting paper listing DfT's priority COVID-19 research questions, and invited comments from SAC members on:

- What are the key long-term opportunities presented by the restart and recovery of transport post-COVID?
- What are the key R&D requirements to take these opportunities?

5.2 The SAC raised the following points:

- There may be a longer-term reduction in travel demand, particularly for commuting and international travel, and an increase in working and accessing services through interactions held remotely. Changes to working patterns may be significant and affect transport needs and impacts.
- On the other hand, operators may still need to consider how to spread out the peaks in their demand to cope with reduced capacity due to social distancing. Since travel is a derived demand, this will require cross-sector coordination. Live data on transport loading can support people's decisions on when to travel and the management of capacity.
- If some people are more able to work remotely this may significantly affect where people choose to live, and alter the demographics and activity in cities, provincial and rural areas.
- An increase in people favouring private vehicle use over public transport is a concern. Good street lighting and infrastructure to support personal safety will be especially important to maintaining active travel use into autumn and winter.
- Special measures may be needed to help the most vulnerable, shielded people move about safely, especially where they are unable to drive.
- The COVID situation has resulted in increased access to and use of a range of data on transport use and other relevant indicators, often available in near real-time. This should be maintained where possible. During the pandemic, companies have been more willing to share data that they consider commercially sensitive, so there may be a tendency to go back on this as the situation eases. An assessment should be conducted of which data streams are most useful, moving forward, to support transport planning and innovation.
- We don't yet understand how the use of personal data as part of measures to control COVID will affect people's longer-term attitudes towards sharing personal data – and this will be important. Data security and trust will be critical to this.
- Longitudinal studies are very important to understand influences on longer-term behaviour.
- Universities and major employers, and their sites, could be valuable in providing living labs with a critical mass of people to develop place-based thinking about new transport solutions.

- With the changes from COVID, there are opportunities to actively disincentivise behaviours and situations that we don't want to return to, especially in support of sustainability and cleaner travel.
- Government support to industry could be made conditional on improving sustainability. However, the economic impacts of COVID will mean that the transport industry will have less of their own money available to fund innovation.
- With changes in demand for long-distance travel there may be an opportunity to adjust the balance of domestic aviation and rail towards rail, in support of decarbonisation.
- COVID has resulted in a trend towards making supply chains more resilient: moving them back to the UK ("reshoring") to reduce reliance on overseas supply, and with more of a time buffer rather than being "just-in-time." This will impact freight and logistics requirements, and needs to be understood.
- This is the sixth pandemic worldwide in the last 15 years; it's vital that lessons are taken – both from things that have gone well, and less well – to help plan our response to the next one and improve our resilience. There are several positive things to take from DfT's and the transport sector's response to the COVID situation. In both the short and longer-term we must also learn from the evidence and experiences in other countries.
- These questions could be considered further through strategic roadmapping sessions, possibly involving the SAC.

6. DfT Science Plan

Creating the ecosystem

6.1 The Head of DfT Office for Science summarised the vision for "a transport R&D ecosystem that focuses on delivering transport priorities; shaping the sector now and into the future," as described in the extract from the draft Transport R&D Strategy document, which had been circulated. SAC members were asked for their thoughts on the following questions:

- What are the current barriers to delivering on the vision; in particular, collaboration mechanisms and methods between Government, industry and academia?
- What immediate priority actions should we take to set the foundations for an enhanced transport R&D ecosystem?

6.2 The SAC made the following points:

- Joining-up across government can be a barrier. This is particularly important for transport, where demand is derived from activities such as employment, education, commerce and services, and which is an enabler for other policy areas. Cross-government coordination is also vital for HM Government's 'levelling-up' agenda.
- Coordination between DfT and BEIS is especially important for transport R&D and topics such as clean energy for transport.
- Industry must be clear about how to engage government and UK Research & Innovation (UKRI) regarding R&D funding, including how to engage in a coordinated way with multiple government departments.

- Further joining up between the Engineering and Physical Science Research Council (EPSRC) and the Economic and Social Research Council (ESRC), via UKRI, would also be beneficial.
- There is some fragmentation in the R&D landscape within and across transport modes. Coordination within all modes, though organisations such as the Aerospace Technology Institute and Advance Propulsion Centre, should be strengthened, as should links across modes and between these organisations.
- Living labs and testbeds can act as strong focal points to bring government, industry and academia together.
- Open competitive tender processes support fairness, but government must still have freedom to collaborate with and fund those with the best ideas and able to deliver them. Private companies with a good initial idea should be able to collaborate with government and have routes to funding while maintaining control of their intellectual property.
- Especially given the economic impact of COVID, industry needs public funding support to de-risk innovation.
- There may be scope for fresh thinking about how government supports industry in light of EU exit and actions taken in response to COVID.
- Increased engagement and collaboration between academia and national-level transport operators would support transport R&D having greater and quicker impact. It can be challenging for academics to engage operators with their research, and there should be action to help facilitate this.
- The lack of Centres for Doctoral Training in transport data show this is not enough of a priority currently for UKRI. Members of the SAC have previously proposed a national Transport Data Innovation Centre.
- The vision statement as written is too generic and doesn't reflect anything specific about current circumstances. The real vision driving the document is about delivering societal/economic/environmental benefits through transport R&D.
- DfT should be clear about where its focus is on supporting transport as an enabler, and where it is on supporting transport as an industry.
- A strategic roadmapping session could be helpful in clarifying the vision, considering how to improve the transport science ecosystem and building consensus on R&D priorities.

R&D priorities

6.3 The Head of DfT Office for Science summarised the R&D priorities framework, as set out in the circulated draft Transport R&D Strategy document. This framework is structured around the four DfT strategic objectives of improving transport for the user, decarbonising transport, leveling-up the economy, and increasing our global impact. SAC members were asked to comment on:

- What high-level R&D needs must we capture under "Improving transport for the user" and "Decarbonising transport," and where should we focus resources to have the greatest impact?
- How do we shape R&D investments to level up the economy/society, and ensure we remain global leaders in transport R&D?

6.4 The SAC had the following comments:

- Resilience doesn't come through strongly enough as a theme, in terms of resilience to pandemics, cyber-attacks, etc.
- We need to be clear whether/where growth in transport or reducing demand is the objective, and the extent to which government and society want to fundamentally change how people travel rather than incrementally improving it.
- It's important to take lessons from and build on the things that DfT have done well in response to COVID.
- We must not look just at transport R&D alone, but integrate it with other sectors and priorities, including 'levelling up', growth and new industries.

Action Log

No.	Action	Owner
20-06/1	Supply summary lines and references on strategic roadmapping	Anna-Marie Greenaway
20-06/2	Revise Influencing travel choices and demand paper and recirculate with tracked changes for final approval	SAC Secretariat
20-06/3	Supply wording on the issue of how AVs will access and interact with the kerbside	Peter Jones
20-06/4	Revise AV human factors paper and recirculate with tracked changes for final approval	SAC Secretariat

Annex G: 23 September 2020 meeting minutes – Aviation sector skills readiness for zero emission aircraft

DfT Science Advisory Council

10:00–12:15 Wednesday 23 September 2020, via videoconference

Minutes

Council members attending

- Prof Lord Robert Mair (Chair)
- Anna-Marie Greenaway
- Prof Peter Jones
- Prof Ricardo Martinez-Botas
- Prof Rob Miller
- Prof Nick Pidgeon
- Prof Sarah Sharples
- Dr Dave Smith
- Prof Paul Watson

DfT attendees

- Jo Bacon, Head of Social and Behavioural Research (items 3 and 4 only)
- Prof Phil Blythe, Chief Scientific Adviser
- Dr Siobhan Campbell, Head of Central Research Team
- Dr Louise Guidi, Private Secretary to the Chief Scientific Adviser
- SAC Secretariat
- Michael Hobson, Head of Science Plan Strategy and Programme
- Asher Lawrence-Cole, Head of Academic and International Engagement, DfT Office for Science
- Dr Phil Martin, DfT COVID-19 Research Coordinator

- Dr Inga Mills, Head of the Transport Research Innovation Board, DfT Office for Science
- Francis Mosley, Assistant Private Secretary to the Chief Scientific Adviser
- Ashley Pressley, Science Plan Senior Policy Adviser
- Simon Shapcott, Head of DfT Office for Science

Attendees for item 6 only

- Greg Easter, Policy Advisor – Aviation Climate Change, DfT
- Holly Greig, Deputy Director – Aviation Climate Change, DfT
- Sarah Leonard, Head of Aviation Skills, DfT
- Ana-Paula Cordeiro, Head of Strategy, Aerospace Technology Institute
- Simon Weeks, Chief Technology Officer, Aerospace Technology Institute
- Mark Westwood, Chief Technology Officer, Connected Places Catapult

Apologies

- Prof Barry Clarke

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1. Welcome and introduction

1.1 The Chair welcomed Prof Rob Miller as a new member of the SAC. Prof Miller is Chair in Aerothermal Technology and Director of the Whittle Laboratory for turbomachinery research at the University of Cambridge. His research is aimed at reducing the emissions of both air travel and land-based power production, on which he works with a very multidisciplinary team and a range of leading companies. We're delighted that he has agreed to join the Council.

2. Review of minutes from June meeting

2.1 The minutes from the June meeting were agreed without any amendments.

3. Update on DfT's science response to COVID-19

3.1 Phil Blythe updated the SAC on science activities supporting DfT's response to the impacts of COVID:

- A COVID Science Cell team has been supporting Phil to provide science advice to policy teams and Ministers on the transmission risks and mitigation measures on transport. This has involved sourcing and translating available evidence, including from the Scientific Advisory Group for Emergencies (SAGE), and identifying evidence gaps to be filled, either in the short or longer term. Currently, there is very limited evidence available on the transmission of COVID-19 specifically associated with transport use.

- Phil and colleagues have supported the development of a UKRI project aiming to model transmission risk on buses and trains, and to assess the effect of potential mitigations. Project TRACK (Transport Risk Assessment for COVID Knowledge) involves several universities and research organisations and is aiming to deliver improved quantification of risk within the next six months. It is hoped that the risk modelling approach and some of the specific analysis will be transferrable to other non-transport settings. Both TRACK and a parallel project led by University College London include sampling for coronavirus on public transport.
- Phil and colleagues are making the case for transport environments to be key scenarios considered throughout the UK Research Councils' core research programme on COVID transmission.

3.2 SAC members raised the following points:

- Is there any evidence available from other countries on the specific risk of transmission on public transport? In response, it was confirmed that DfT and others have looked at this, but very little exists.
- Are there settings that are analogous to public transport where better evidence for transmission risk might exist, and could then be translated to transport?
- Given the limitations of available evidence it is essential that uncertainties are clearly communicated to policy officials and Ministers.
- We have seen during the pandemic the importance of the framing and context of messaging to how people assess risk and choose to act. Messaging and response is a significant factor that must be considered when assessing evidence on transmission risk and the effectiveness of mitigation measures. The later stages of the TRACK programme should consider effective communication of risk.
- People don't generally have very accurate mental models of COVID transmission mechanisms and the reasoning behind rules to inform their perception of risk. Other factors that significantly affect perception of risk[3] include heightened levels of anxiety, personal experience of COVID illness in others, and levels of familiarity with specific environments and situations.
- The House of Lords Science & Technology Committee's enquiry into "The Science of COVID-19" (in which Lord Mair is involved) is currently considering such psychological aspects, including personal assessment of risk, levels of trust in messaging from authorities, fatigue with the COVID situation, and correlations with mental health.
- Rather than waiting and relying on a future extension of QR codes within the NHS Test and Trace app, could we independently trial such an approach locally to get useful data on transmission on transport sooner? Data from such approaches could possibly also be correlated with CCTV image data for further insights.

[3] Sarah Dryhurst *et al* (2020): Risk perceptions of COVID-19 around the world, Journal of Risk Research, https://doi.org/10.1080/13669877.2020.1758193

4. How social and behavioural research is supporting DfT's response to COVID-19

4.1 Jo Bacon provided an overview of DfT's social research and behavioural science programme relating to COVID-19, summarising the paper provided in advance.

4.2 The SAC was asked:

- Does the SAC have advice on how to engage academia with this, to join up and get most value from it at a strategic level?
- Are there any key research questions missing, that should be included in taking forward DfT's research programme in this area?

4.3 The SAC made the following comments:

- The SAC congratulated those involved for the amount of good evidence obtained in a short space of time and the work's consideration of vulnerable groups.
- A meeting could be convened with academia in a few months' time to share and publicise these data, focusing on supporting the 'green recovery.'
- UKRI might consider setting up a network to support dissemination of results and communication between government and academia on 'green recovery' issues.
- Academia may be able to assist with integrating this data with additional quantitative data, to obtain further insights.
- Good data visualization will help communicate these results, especially to decision makers. There is lots of current activity on effective data visualization, including by the Alan Turing Institute.
- Data collected during the current, highly unusual circumstances may be a poor predictor of future behaviours, even if the shift to more working, education, shopping and services being online seems likely to persist. Results should be treated with caution and uncertainty or caveats clearly communicated.
- Focusing on evidence needs around supporting active travel would be valuable to the restart.
- The Citizens Climate Assembly concluded that action should be taken to address the climate impact of frequent flyers. The SAC suggested thatit may be useful for DfT to follow this up within this work.
- Under current restrictions, university campuses will still have large numbers of people on site and could be valuable 'living labs' to test messaging and response around transport use and safety measures, and related attitudes and impacts.
- There may be learning from other countries on the different public responses to more consistent or flexible government messaging. However, it was noted that evaluation evidence of such factors was currently lacking.

5. Update on DfT Science Plan

5.1 Michael Hobson provided an update on the Science Plan work, covering:

- the R&D Statement, which provided a strategic narrative bringing together all DfT's R&D proposals for the Spending Review
- the planned science governance system within the department.

5.2 The SAC raised the following comments:

- Priority outcomes should be clearly articulated, from which it should then be apparent that the proposed strategy and organisational structure are the best way to deliver these outcomes.
- The structure could provide a greater sense of a single, coherent and compelling programme, and more clarity on who owns this mission.
- A lot of responsibility and emphasis is placed on the role of the Chief Scientific Adviser – possibly too much for a single role.
- The work should consider how local authorities and regional groups will engage with the proposed governance structure. In response, it was noted that such organisations are represented on the Transport Research and Innovation Board (TRIB) by the Association of Directors of Environment, Economy, Planning & Transport (ADEPT) and Transport for the North.

6. Aviation sector skills readiness for zero emission aircraft

6.1 The Chair welcomed additional attendees for this item.

6.2 Holly Greig Deputy Director – Aviation Climate Change, DfT, introduced the item. DfT anticipates battery and hydrogen propelled aircraft to be in the commercial market by 2030, and is seeking to build an evidence base of how the aviation workforce will need to adapt.

6.3 Simon Weeks, Chief Technology Officer, Aerospace Technology Institute, introduced the ATI's Fly Zero project. This aims to realise a zero-carbon emission commercial aircraft by the end of the decade, through: understanding all major technical and commercial issues; establishing the business cases for investment; and sustaining and developing key capabilities.

6.4 Sarah Leonard, Head of Aviation Skills, DfT, introduced the Reach for the Sky programme. This will "inspire the next generation of aviation professionals, making aviation diverse, inclusive and accessible to all" by raising the profile of aviation, developing clear career pathways and supporting skills and training.

6.5 The meeting was invited to consider the following questions:

- How can we best understand how to prepare the aviation workforce for the introduction of new technology whilst there is ambiguity over the precise technological solutions which will be adopted?
- Will we require an Aviation-specific or cross-transport approach to future workforce issues involving zero-emission technology? Are there potential opportunities to generate transferable skills across transport modes, such as from electric vehicles?
- How can we use the early adoption of electric aircraft technology by recreational pilots and SMEs to accelerate the development of a skills transition for scheduled aviation?
- Are there ways we can better communicate the potential near-future STEM job opportunities this technology should provide, to attract those in education, those entering the workforce and skilled individuals overseas?

6.6 The SAC made the following points:

- The change in the workforce and skills will certainly be significant, but the existing skills of the majority of the sector workforce will still remain relevant to future aviation. There is, however, uncertainty in how technology will develop and affect skills requirements; multiple alternative fuels need to be developed and deployed, including sustainable aviation fuels, and hydrogen combustion technology now seems likely to be more significant than previously thought.
- There is enormous scope for developing and moving skills across the transport sector and more widely, where electric propulsion, hydrogen, hydrogen fuel cells, energy supply and automation are common themes.
- This is not a new problem in the transport sector, and lessons can be learnt from the change in automotive sector skills from the move towards electric and fuel cell vehicles.
- More generally, other industries have gone through big changes - including computing, where we have seen new companies disrupt the industry at the expense of some established incumbents. We may expect to see some smaller, more agile companies make the quickest advances in zero emission flight. Larger companies typically adapt through a combination of paying high salaries to secure able and adaptable employees; changing or broadening the skills they recruit; acquiring 'disruptor' companies with innovative technologies or approaches; investing in their own R&D.
- While the aerospace technology ecosystem is well integrated, this is less true of the aviation sector as a whole. Government can play a role in convening the aviation sector on decarbonisation to ensure progress not only on aircraft technology but also air space modernisation, airfield operations and surface access to airports. The Industrial Strategy Challenge Fund (ISCF) Future Flight Challenge is focussed upon small aircraft and autonomy - is there a need for a similar programme for larger 'clean' aircraft?
- Several SAC members endorsed a recent address by HRH the Prince of Wales in which he advocated ten actions to accelerate the decarbonisation of flight. Of relevance to skills, these included co-locating teams comprising industry, academia and government to address the most complex challenges; developing credible independent roadmaps to accelerate delivery; and accelerating adoption of SAFs and development of hydrogen and electric flight.
- Clusters of activity with co-located SMEs, particularly centred around universities, are valuable in driving forward innovation and should be supported. The ISCF Future Flight programme, and the government's overarching agenda to level-up the economy across the UK, may generate some new clusters, rather than only maintaining existing ones.
- Strategic roadmapping and an agile approach can support an acceleration of change. This is the approach and objective of the Aviation Impact Accelerator set-up by Prof Rob Miller. Communicating roadmaps that highlight how and when technology will develop can support workforce planning and build interest within the public and potential workforce.
- Young people are excited by jobs that contribute to addressing climate change and sustainability, as well as technological innovation. These themes should be emphasised in advertising training and employment opportunities, to attract people to aviation and to green transport engineering as a whole. Smaller, quicker-to-market electric/hydrogen aircraft can generate the excitement to attract skilled workers.
- Our education and training systems need to support changing skills requirements, and excite students about the opportunities in clean aviation. University curricula

should be forward-looking while teaching subject fundamentals that will remain relevant across the development of different, specific technologies, and a wider skills set including a systems engineering/thinking approach. PhDs will provide more specific training.

6.7 HM Government's new Jet Zero Council will be followed by further activity to convene views on this issue in relation to the whole aviation ecosystem and infrastructure, so there will be further opportunities for input. Attendees agreed that clean aviation is a big opportunity for the UK, if we can get it right.

Annex H: 25 November 2020 meeting minutes – Capital carbon in infrastructure

DfT Science Advisory Council

12:45–15:00 Wednesday 25 November 2020, via videoconference

Minutes

Council Members attending

- Prof Lord Robert Mair, Chair
- Prof Barry Clarke
- Anna-Marie Greenaway
- Prof Peter Jones
- Prof Ricardo Martinez-Botas
- Prof Rob Miller
- Prof Nick Pidgeon
- Dr Dave Smith
- Prof Paul Watson

DfT Attendees

- Prof Phil Blythe, Chief Scientific Adviser
- Dr Siobhan Campbell, Head of Central Research Team
- Private Secretary to the Chief Scientific Adviser
- SAC Secretariat
- DfT COVID-19 Research Coordinator (not item 4)
- Head of the Transport Research Innovation Board
- Head of Innovation, Futures and Decarbonisation – Office for Science
- Head of Governance, Strategy and Capability – Office for Science

Attendees for item 4 only

- Head of Transport Infrastructure Efficiency Strategy, DfT

- Lucy Kavanagh, Deputy Director – Environmental, International and Regulatory Analysis, DfT
- Policy Adviser, Portfolio and Project Delivery, DfT
- Tim Chapman, Director – Net Zero Carbon for Infrastructure, Arup
- Simona Dobrescu, Environmental Lead – Project Futures, Infrastructure and Projects Authority
- Dr Jannik Giesekam, Research Fellow in Industrial Climate Policy, University of Leeds
- Fergus Harradence, Deputy Director – Construction, Department for Business, Energy and Industrial Strategy
- Dr Richard Leese, Director – MPA Cement, Industrial Policy, Energy and Climate Change, Mineral Products Association
- Dr Zushu Li, Reader and EPSRC Fellow in Manufacturing, University of Warwick
- Dr John Orr, Lecturer and EPSRC Fellow in Concrete Structures, University of Cambridge
- Neil Wait, Environmental Manager, HS2 Ltd

Apologies

- Prof Sarah Sharples

These minutes record the views and opinions expressed during the meeting, without generally attributing these to individual attendees. Individual opinions may not be the view of the SAC or group of attendees as a whole and should not be taken as an indication of HM Government policy.

1. Welcome and introduction

1.1 The Chair welcomed everyone to the meeting and noted apologies. The new Head of Governance, Strategy and Capability in DfT's Office for Science introduced themselves.

2. Review of minutes from September meeting

2.1 The minutes from the September meeting were agreed without any amendments.

2.2 The Chair noted that section 6 of the minutes had been provided to the DfT aviation policy team as the output from the discussion on aviation sector skills for zero emission aircraft.

3. DfT's science response to COVID-19

3.1 Phil Blythe updated the SAC on recent science activities supporting DfT's response to the impacts of COVID, including:

- current evidence on transmission
- the UKRI project TRACK (Transport Risk Assessment for COVID Knowledge), in which DfT are involved
- evidence on predicted travel for Christmas and students returning home from universities

- the COVID recovery theme within DfT's current Transport-Technology Research and Innovation Grants (T-TRIG) competition.

3.2 DfT COVID-19 Research Coordinator introduced the paper on DfT's priority COVID research questions and summarised how these had been collated and prioritised from across the Department. The SAC was asked:

- Do members have comments on the prioritisation of research questions and whether there are gaps?
- Do members have suggestions for links to existing external research activity that would help DfT address these questions?

3.3 SAC members raised the following points:

- Overall the SAC felt these were a good set of priorities.
- DfT should be clear whether these questions reflect taking a UK-wide approach to response and recovery. Alternatively, what evidence exists or is needed on supporting different approaches in different nations and regions of the UK?
- The paper and questions could more clearly reference where differences between urban and rural settings may need to be considered.
- Prioritisation could usefully be based on clear criteria reflecting clear intent. These could include: the minimum that needs to be done to get back to 'normal' (which should reflect scenarios for the impact of vaccination programmes); a clearer vision for the better, future ‘normal’ that government is aiming for; the value offered to economic growth, levelling-up and related priorities; the questions that need answering for the transport system to be resilient and respond effectively to different scenarios of a future pandemic, e.g. understanding what are the easiest and best options to maintain a functioning transport system.
- It seems to remain key to obtain further evidence on virus transmission in a confined transport environment with some ventilation.
- Is there a need for increased monitoring of how transport services are operating in practice, to understand how well mitigation measures are working?
- Monitoring of behaviour needs to recognise that it can change very quickly – for example, it may have changed already in response to a vaccine now being on the horizon.
- DfT would benefit from better understanding and carefully considering how to communicate risk where there is emerging science and significant uncertainty.
- The National Traffic Survey (NTS) may benefit from alterations or additions to reflect COVID-related changes in behaviour. It was noted that no additions to the NTS have been made so far, but that DfT have a specific longitudinal study, All Change?, looking at COVID-related changes.
- The research questions should be considered in the context of EU Exit – for example, what does EU Exit mean to resilience, and what does resilience to a pandemic mean to a post-EU Exit economy?
- Recovery plans could consider demand management, informed by an understanding of which services could most readily remain online/remote for now, or where services might go to users instead of users travelling to them.
- New data streams have been key to the transport response to COVID; much of this data should now be gathered and made available routinely, not just in response to

immediate need. As the SAC have suggested before, there is a case for a new critical national transport data infrastructure to support this.
- When engaging with UKRI and others, DfT should ask about all COVID-related science, so that they are the ones able to decide whether it is relevant to transport.
- DfT should engage with top social scientists and experimental psychologists to ensure questions, surveys, and their responses are meaningful.
- Some specific research was noted on air flows and ventilation affecting transmission, and Dave Smith offered to provide links post-meeting.
- The Centre for Climate and Social Transformations' (CAST) have a programme on the impact of the COVID 'moment of change' on attitudes, including in relation to transport, which will be relevant.
- Airlines are currently doing a lot of customer engagement to try and understand how to encourage people back onto planes; this could be very informative if DfT were able to access some of this.
- Many organisations (e.g. McKinsey) are looking at expected changes to work patterns and car sales.

4. Capital carbon in transport infrastructure projects

4.1 The Chair welcomed attendees for this item and noted the background paper provided in advance to frame the discussion.

4.2 An introduction was given to the challenge for the Department around infrastructure capital carbon, noting the following points:

- In 2018 it was projected that there would be £120bn of public and private investment in UK transport infrastructure over the subsequent decade, comprising 20% of the £600bn total infrastructure investment across all sectors.
- Greenhouse gas emissions associated with the whole lifecycle of infrastructure are expected to become an increasingly significant proportion of total UK emissions as other sectors continue to decarbonise towards 2050.
- For some transport projects, capital carbon emissions associated with construction and maintenance are significant compared to the emissions from the infrastructure's operation and use. The ability to influence these emissions reduces rapidly from the initial design stages of projects.
- The Transport Decarbonisation Plan currently being developed by DfT addresses transport use but not infrastructure's capital emissions. There is a need to think about all emissions in a joined-up way, including bridging between the transport and construction sectors.
- DfT intends to strengthen how capital carbon is assessed and reported across its major infrastructure projects to inform decision-making, including developing a more consistent approach and greater sharing of comparable data.

4.3 Jannik Giesekam, from University of Leeds, presented on capital carbon of transportation infrastructure:

- Capital carbon or embodied carbon are the terms for emissions associated with the whole lifecycle of an asset excluding its use (user carbon) and in-use operation (operational carbon, e.g. from road lighting).

- Capital and operational carbon emissions from major infrastructure (energy, communication, transport, waste and water) contribute 13% (99 Mega tonnes of CO2 equivalent per annum (MtCO2e p.a.)) of the UK's total carbon footprint. These sectors can influence a further 41% of UK emissions coming from end-users of the infrastructure.
- Across all UK infrastructure, both user and operational carbon have reduced in the last decade. However, infrastructure capital carbon, although currently a much smaller contribution to the total, increased by 60% from 2010 to 2018.
- Dr Giesekam estimates that capital carbon from transport infrastructure is close to 10 MtCO2e p.a., or nearly one-fifth of the total capital carbon from all UK construction, including both infrastructure and buildings. Based on future transport infrastructure plans and estimated carbon intensity this could continue at a similar level over coming decades.
- Completely decarbonising the electricity grid would only get rid of about 20% of capital carbon.
- Estimates of future infrastructure capital carbon depend on the carbon intensity per unit of capital spend, which varies widely (100-900 tCO2e/£m) by contractor and project. As a positive example, one leading tier one contractor has reduced their average carbon intensity from 351 tCO2e/£m in 2010 to 215 tCO2e/£m in 2018, and is aiming to reach 130 tCO2e/£m by 2030.
- Total capital carbon associated with the whole lifecycles of the HS2, Heathrow third runway and A14 extension projects are approximately 13, 4 and 1 MtCO2e respectively.
- Capital carbon is increasingly assessed for individual assets, projects and asset portfolios. However, unlike user carbon and operational carbon, capital carbon is rarely assessed in the highest-level investment plans, such as the National Infrastructure Strategy or Road Investment Strategy 2, and the integrated systems models and future scenarios supporting them.
- Current reporting standards (e.g. Design Manual for Roads and Bridges LA114 Climate) deem capital carbon from individual projects (even large ones such as the A14 extension) to be insignificant to HM Government carbon targets, leading to their sizeable collective impact being poorly assessed and understood.
- The lack of official assessment of capital carbon across transport, e.g. for the roads network, hinders decision-making and invites unofficial estimates and potential challenge. Transparent, central estimates should be made instead.
- Capital carbon will become the next major challenge in delivering net-zero transport system. DfT should implement routine programme/portfolio level assessment of capital carbon; integrate capital carbon into system models; and pre-empt potential challenge through transparent data and decision making.

4.4 A presentation was given on DfT's Transport Infrastructure Efficiency Strategy (TIES), and how it can support the development of data systems for monitoring capital carbon and promote carbon-saving construction efficiencies:

- TIES aims to improve the assurance and completeness of project performance information to drive efficiencies and innovation. This is primarily about whole-life costs and the data to understand the drivers of these, but can also support assessment and reduction of capital carbon.

- One goal of TIES is to accelerate the wider adoption of Modern Methods of Construction (MMC) through a living lab and benchmarking of the opportunities they provide, including a reduction in carbon.
- As is the case for costs, data on the drivers of capital carbon are currently not good enough. DfT needs to be able to benchmark across major projects for different modes of transport, but there isn't a consistent method used to assess carbon across these projects and the arm's length bodies delivering them. Consensus is building around the Publicly Available Specification (PAS) 2080:2016 for Carbon Management in Infrastructure as a standard for good practice.
- By evidencing the drivers of costs and carbon impacts, and the potential for whole-life savings, TIES aims to support culture change in how major projects are commissioned, designed and managed.

4.5 Richard Leese, from the Mineral Products Association, presented on the UK Concrete and Cement Industry Roadmap to Beyond Net Zero, making the following points:

- In 2018 the UK concrete and cement sector contributed 1.5% of total UK greenhouse gas emissions and had reduced its emissions by 53% from 1990 levels (which compares to a 43% reduction across all UK emissions.)
- Compared to 2018 levels (100%), the sector plans to achieve net zero by 2050 through a combination of decarbonised electricity supply (−4%), cleaner transport (−7%), low carbon cement and concrete formulations (−12%), switching of fuels for production kilns (−16%), and carbon capture, usage and storage (CCUS, −61%). It was noted that 43% of kiln energy demands in the UK currently come from waste-derived alternatives to coal.
- The roadmap ascribes potential for the sector to make negative contributions to downstream emissions through the chemical absorption of atmospheric carbon by concrete over time (carbonation, credited as equating to −12% of the industry's 2018 emissions) and the benefits of the thermal mass of concrete in reducing the energy needed to heat and cool buildings (−44%)
- The roadmap does not include carbon offsetting or offshoring emissions, or promote the importing of goods to meet carbon budgets. The transition to net zero should not compromise the competitiveness of the UK industry. 23% of cement used in the UK is currently imported, despite the fact we have all the raw materials in the UK.
- Government should enable the transition to net zero concrete and cement through greenhouse gas accounting mechanisms, regulation, and provision of finance and infrastructure.
- Current low-carbon cements are generally focused on niche applications since they compromise properties such as concrete strength or durability. A consortium including MPA are developing low-carbon cement formulations for general purpose concrete with up to 60% lower carbon than the current market leader, and this will modify the British Standard for concrete (BS 8500).
- Another MPA project funded by BEIS will demonstrates a net-zero fuel mix for cement production, using biomass and hydrogen.

4.6 Attendees were invited to discuss what they had heard and to consider the following questions:

- What are the key challenges to reducing capital carbon in transport infrastructure to contribute to upcoming Carbon Budgets and Net-Zero by 2050, and what potential opportunities are there to address these?
- How can DfT enable and accelerate solutions through the decisions and approaches it takes with its major infrastructure projects?
- Are there common challenges with addressing capital carbon in other areas of transport, or other sectors, where learning and approaches might be shared?

4.7 In response, a range of independent views were contributed by SAC members and other attendees:

- Major projects currently being considered and progressed may not be finished for many years, but the decisions we take on them now will influence our ability to deliver net zero by 2050. It is important to plan and design now for low whole-life carbon, given the importance of very early project stages in fixing this. A key message from suppliers is the need to have conversations about capital and whole-life carbon early in project pipelines.
- Given the imperative to decarbonise, and the technical and economic challenges of decarbonising construction, we need to have a bias for action now, using the levers and technologies currently available – e.g. efficiencies such as 'lean' design to reduce the volume of materials used. Progress in doing so has been too slow in recent years, and a step change is needed.
- Decarbonising cement will be difficult and costly and some of the positive ambition presented by Richard Leese was challenged. Expecting CCUS to remove 60% of that industry's emissions may be optimistic, and some attendees felt it shouldn't be relied on; the implementation of CCUS seems to always remain '15 years away', with the storage aspect especially challenging. It has also been forecast that CCUS could double the price of cement. Furthermore, although the UK concrete and cement industry's emissions reduced by 53% between 1990 and 2018, it was pointed out that this reduction has slowed significantly in the last decade (3% reduction since 2011).
- Alongside concrete and steel, excavated earth (i.e. soil and rock) is another key material in the construction of infrastructure, and its use should also be considered in relation to reducing capital carbon.
- Maintenance as well as construction is a significant factor in capital carbon, and should be considered from the outset. Resilience and adaptation to climate change are related, important considerations for the whole-life value of infrastructure, including in terms of carbon.
- While capital carbon is increasingly significant, it is currently still a relatively small component of total infrastructure carbon. The critical thing is 'spending' our capital carbon carefully to build infrastructure that will enable us to be a low-carbon society in future and meet our overall carbon reduction targets, as well as serving society as a whole and supporting levelling-up across the country. Hopefully this will be supported by the revised Green Book on HM Government appraisal guidance, being published today.
- DfT could draw wide boundaries when considering projects' impact on overall whole-life carbon, and join-up policy to minimise this. HS2 Ltd say that the project will not 'pay back' its capital carbon and have an overall carbon neutral impact for around 80 years, but it was suggested that this could be a lot shorter if Government put in place complementary freight regulations to maximise the benefits of HS2 in moving freight from roads to the rail network. The impact of this could include building less roads.

- Related to this are the questions of what is included when considering the net carbon of construction; what good looks like as capital carbon becomes a bigger proportion of overall emissions; and how much allowance will there be for the construction sector within the residual emissions expected to remain in 2050 (to be cancelled by removal of carbon from the atmosphere)?
- As with other issues, consideration of this topic must identify, acknowledge and address key uncertainties. Those with different perspectives and interests will always point to different data and assessments within the bounds of reasonable uncertainty.
- Embedding whole-life carbon assessment and reporting across Government is vital and will provide signalling to industry on this issue. The issue raised in Dr Giesekam's presentation, that carbon from individual projects is only considered against UK total emission targets, was recognised as a problem, and not generally mirrored in our approach to emissions in other sectors.
- Encouraging and enabling innovation in the sector is key. The construction industry often finds it challenging to innovate due to its low margins and complex collaborations for delivery. Given the rate of progress to this point and the urgency to act, more regulation may be needed to drive this innovation.
- Roadmapping the route to decarbonisation is an important process, and it is good to see examples of industry taking a lead in this.
- The experience of HS2 has been that a focus on carbon must be led from the very top of the organisation to be embedded and to translate through to project requirements and contracts. HS2 Ltd's recent PAS20:80 certification is a positive step forward. HS2 has the advantages that it must innovate to deliver its project, and that it has the scale to be able to drive this.
- Standardisation of carbon assessment and reporting across the industry is critical. This has been key in the energy industry. Standardisation enables accurate comparison and informed decisions, and is part of the answer to addressing uncertainties that may hinder concerted progress. It was suggested that the development of a global carbon standard for cement might be a suitable ambition to be linked to the UK's hosting of COP26. It was noted that the Green Construction Board is currently looking at definitions for low carbon concrete, which has wide industry support including the involvement of MPA.
- Some measures to reduce carbon can support reduced costs, but in general government needs to be prepared to pay more (at least upfront) for lower whole-life carbon. The value of carbon must be appropriately factored into project appraisal through changes to the Green Book, and the barrier to projects should be higher if they are not going to support net zero. Government should consider incentivising designers and contractors to deliver projects with less capital carbon.
- Carbon needs to be seen as a key design criterion in all projects – which isn't the case currently – and DfT can drive this as a major client. This requires culture change but also upskilling those already within the industry and developing the right skills in new graduates. All those involved in the industry up to chief executives need to be 'carbon literate.' Data skills will be part of the requirement, and perhaps the environmental angle can attract data scientists and others who might not typically be drawn to the construction industry.