Department for Transport

DfT Science Advisory Council
Annual Report 2016

Moving Britain Ahead

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Foreword by the DfT Chief Scientific Adviser (CSA)

This is an extremely exciting time to be thinking about transport science and technology: the pace and nature of innovation in this sector, coupled with the challenges of operationalising them, means that there is no better time to be DfT's Chief Scientific Adviser (CSA).

My role as the CSA is to ensure that the Department's scientific and engineering activities are well directed and that DfT's policies are based on sound evidence. This means providing challenge and advice in order to ensure that both the right research is commissioned and that high-quality scientific and engineering evidence is used in policy development and delivery. Identifying, understanding and utilising science and technology will be central to the Department's ability to deliver its ambitious programme of infrastructure and transport systems improvements and meet the challenges that come with fast-paced innovation.

The Science Advisory Council (SAC) helps me deliver this role, and support DfT's Ministers and Senior Officials in their decision-making. The SAC provides insight and challenge across the breadth of DfT's areas of responsibility and contains and can convene a very wide range of expertise in science, social science and engineering.

The Council was first formed in January 2014 and the value it brings to the Department is evident from the interaction and engagement the Council has with DfT and its supporting agencies and public bodies. The Council has made good progress since its creation and has continued to build on that momentum becoming both a critical friend of the Department providing strategic level advice and also acting as a point of challenge to support the Department on science and engineering issues. As covered in this annual report, members of the Council have been instrumental in providing a strategic overview on a number of topical issues and helped strengthen the Department's relationship with the wider academic and industry communities.

This year has seen the Council provide advice and analysis on a range of issues from Hyperloop to Cyber Security. Furthermore, the Council has provided a more strategic outlook on how the Department could incorporate innovation and systems thinking in delivering its objectives.

I would like to thank the members of the SAC, and in particular, the Chair, Professor Lord Mair, for their time and contribution in what was a challenging but successful year.

Phil Blythe

Foreword by Chair of the Council

The primary role of the DfT Science Advisory Council is to provide strategic independent advice and challenge to the Department on key Science, and Technology issues.

The Council is tasked with ensuring the DfT has a shared understanding of the evidence needs required to support policy across a broad portfolio. The Council supports the Chief Scientific Adviser (CSA) in his role, by ensuring that policy development takes account of broader academic engagement and that scientific evidence underpinning policy and delivery is robust. The constructive challenge from the Council has helped highlight uncertainties and provided strategic steer on a range of very important topics.

In 2016, we have covered and provided advice and challenge on a range of topics that span the broad spectrum of science and engineering issues associated with transport. We have also influenced the strategic approach the Department takes in relation to innovation, including a systems thinking approach in developing its evidence base.

The Council has once again had the opportunity to engage with senior officials in the Department. Most notably, we have had very effective and influential discussions with the Permanent Secretary and Directors General to discuss Intelligent Infrastructure & Condition Monitoring and Customer Satisfaction. This level of engagement recognises the significance of scientific evidence in policy development and their engagement has been a key feature of the Council's operation.

It is important that the Council maintains independence and can initiate topics to be considered as well as respond to the challenging needs of the Department. We have discussed a number of technical topics, as well as take a foresight look at emerging issues such as Hyperloop. We have had the opportunity to better understand how innovation is used within DfT, providing advice on how to encourage and enable innovation in transport.

Finally, I have had the pleasure of continuing to Chair of the Council and would like to acknowledge the commitment, contribution and enthusiasm shown by my fellow members. I believe we have strengthened the Department's relationship with the wider academic and scientific communities and look

forward to continuing to work with the Department's CSA to support and challenge the DfT on its use of science and engineering evidence.

Professor Lord Robert Mair

1. Executive Summary

The DfT Science Advisory Council (SAC) is an advisory body that provides independent expert advice on science policy and strategy to the Department. The membership and terms of reference for the council can be found in Annex A and B respectively.

In 2016, the DfT Science Advisory Council has continued to build on the momentum established in previous years, through providing advice and challenge on a wide range of topical transport science and technology areas, including Cyber and Data and Hyperloop.

Furthermore, following their discussions, the Council has published two position papers on their deliberations on Customer Satisfaction Measures in Transport and Condition monitoring and Intelligent Infrastructure and these outcomes have been discussed with senior officials in the Department. The Council has also maintained a role as a foresight thinker, undertaking horizon scanning to highlight emerging issues that the Department should consider in the near future.

The Council has made a significant contribution to a range of Science and Technology policy areas, most notably by providing a number of observations and recommendations in regard to Hyperloop, providing a useful overview of the practicality and potential of the technology for the UK. Likewise, it has provided advice on security considerations for Connected and Autonomous Vehicles.

Valuable support was provided by the Council on the Department's Evidence and Research Summaries, through supporting the dissemination of the Department's Areas of Research Interest across academia and providing recommendations on ways for the Department to better utilise and inform research undertaken by the UK's Research Councils.

Moreover, individual member's expertise were continued to be called upon by the Department and wider government, especially with substantial input into the Vehicle Emissions Testing Programme and the Council providing advice to the Department on next steps for going forward.

Overall, the SAC has continued to provide valuable resource of strategic science and technology advice for the Department, making a significant impact on a number of cross-cutting areas.

2. Introduction to the Science Advisory Council

The DfT Science Advisory Council (SAC) was established in 2014 with the aim of providing strategic advice and challenge to the Department for Transport on key Science and technology areas. This is the third annual report of the SAC and covers its activities in 2016.

The Council's membership is formed of eminent individuals from academia and industry. It supports the Chief Scientific Adviser (CSA) in both ensuring DfT key policies (and service delivery) are underpinned by the best evidence, and in strengthening the Department's relationship with the wider academic community. It takes account of emerging technological trends that could impact the transport system.

Broadly, the specific activities undertaken by the Council include:

- Horizon scanning - considering how emerging trends and developments might potentially affect current policy and practice.
- Reviewing departmental strategic evidence plans.
- Strengthening links with the academic community.
- Advising on specific requests from officials.
- Advising on the quality of evidence processes, capacity and capability within the Department.

This annual report provides an overview of the Council's activities over the period and shows the impact of the Council through providing an outline of the discussion topics held throughout the year and highlighting the key recommendations and advice given by the Council. In doing so, it meets the Government's requirements of openness and transparency as promoted by the Civil Service Reform for open policy making[1].

The report also provides an overview of the structure and model of how the Council operates and interacts with the Department. Biographies of the Council's members during 2016 can be found in Annex A and the Terms of Reference for the Council can be found in Annex B.

[1] http://www.civilservice.gov.uk/wp-content/uploads/2012/06/Civil-Service-Reform-Plan-acc-final.pdf

3. Council Discussion Topics

Over 2016, the Council provided valuable advice and challenge to the Department in the following areas:

- Systems Thinking
- Innovation
- Cyber and Data
- Hyperloop

For each of these discussions the key points raised by the Council are summarised below, highlighting the opportunities and challenges they identified for these areas. Further information on these discussions can be found in the relevant meeting minutes, provided in Annexes C–F.

Systems Thinking – 24th February 2016

Systems thinking is a simple but powerful approach to understanding complexity from a number of different viewpoints, demonstrating how the system itself can cause people to behave in similar ways. The use of systems thinking can enable the anticipation of the consequences of decisions, identify gaps in knowledge and involve people. This approach supports evidence based decision making and the delivery of complex projects which involve multiple stakeholders and solutions.

The Council was invited by DfT to discuss how systems thinking could specifically be applied to transport, identifying the benefits and ways to apply systems thinking in the sector, alongside raising awareness of this approach through the participation of key stakeholders from across Government, Academia and cross-sector organisations. Experts in systems thinking presented to the Council, providing an overview of the subject and use case examples.

Following this discussion the Council raised the following key points:

- Systems thinking needs to be continued to be embedded and encouraged within the Department.
- There are a number of good examples of systems thinking being used, for instance in the Office for Low Emission Vehicles.
- The Council would be more than happy to support and assist DfT in applying these techniques to its policy and delivery work.

Following the SAC support of Systems Thinking a series of workshops were held by and for DfT staff to provide the tools to allow a systems thinking approach to be used by policy colleagues. The minutes of this meeting are provided in Annex C.

Innovation – 29th April 2016

New technology is rapidly transforming how the transport systems work, increasing capacity, improving safety and making journeys better for all. To support the uptake and development of innovation in transport the DfT undertakes a number of activities which fund innovation including the Transport-Technology Innovation Grants (T-TRIG), a scheme focused on funding innovative early stage research projects.

The Council was invited to comment on DfT's existing and proposed innovation activities and their role in enabling the Department to deliver against its priorities. The innovation being used to support the construction of Crossrail and the results of an innovation Air Quality grant were presented to the Council.

The Council provided valuable advice to the Department on encouraging innovation and using technology, including the following:

- Procurement processes within Government should incorporate and enable innovation.
- Developing transport technology with seed funding is well supported through initiatives such as the Transport Technology Research Innovation Grants (T-TRIG), but there is a significant challenge to scale up technology and enable it to get to market, especially for small to medium enterprises (SMEs).
- Challenge led funding should be encouraged, such as the proposed Innovation Challenge Fund (ICF).
- Continuing to encourage and foster an environment for innovation at the DfT will bring value to delivering its priorities.

Following the recommendations of the SAC, to support SMEs the T-TRIG completion was changed to provided up to 40% as an initial payment. In addition the ICF initiative, which was supported by the Council, was launched and addressed challenges in the following 3 areas:

- Realising the benefits from unmanned and remotely piloted aircraft systems (drones)
- Doubling cycling by 2025.
- Improving driver training.

The minutes of this meeting are provided in Annex D.

Cyber and Data – 20th July 2016

Data and information in transport is being used more and more in transport, radically transforming how the transport systems work. One key part of this transformational change is the connection and automation of cars, which are instrumental in the development of Connected and Autonomous Vehicles (CAVs); however, in this more connected world, there are potential risks around ensuring the security of these systems and therefore there is a role for Government to raise the profile of and challenge industry on this issues.

The Council was invited to review DfT's approach to Cybersecurity for CAVs, drawing on the Council's significant expertise to improve and identify additional avenues that could be considered. In particular, DfT asked the Council to consider the following:

- What could the role of Government be to ensure the cyber security of the CAV ecosystem?
- What lessons can we learn from other fields?
- What approaches could be used to ensure cyber security is embedded within the automotive supply chain?
- Where might there be industrial opportunities for the UK?

In response to these questions and the surrounding discussion, the Council provided insight into this area and highlighted the following key points:

- Other areas of transport, such as aviation, would be useful to draw lessons from as they face similar issues and risks in this space.
- There are opportunities to use security to address both environment and safety issues.
- It should be ensured that CAVs have a forensic footprint to enable accident investigation. Reporting and learning on near misses should also be considered.
- Government has a role to play in bringing together key groups and people to develop standards and security, for instance the British Standards Institution.
- Government should consider its role in promoting manufacturers learning from each other in this space.

The minutes of this meeting are provided in Annex E.

Hyperloop – 26th October 2016

Hyperloop is a radical new method for transporting passengers and freight at high speeds (700mph). The proposed Hyperloop system typically involves using a combination of sealed pods, which travel in a near vacuum environment and are suspended above the tracks. These would result in considerably reducing the amount of friction encountered by the vehicle, enabling travel at high speeds and increasing energy efficiency.

The technology was first proposed by the American entrepreneur Elon Musk in 2013, and since then the technology has gathered a significant amount of interest and a number of organisations are working to commercialise this technology.

The Council was challenged by the Department to access the feasibility of this technology, the opportunities for the UK, how it could fit with the wider UK transport system, and asked to address the following four questions:

- Does the overall Hyperloop concept appear credible from a technical perspective?
- What do you see as the main technical challenges around the propulsion and control systems and the physical construction?
- What opportunities could Hyperloop offer to UK industry given our technology and engineering expertise?
- Assuming Hyperloop becomes a viable transport system, how would it fit with existing transport infrastructure and what implications might it have for wider infrastructure development e.g., housing, education, health?

After discussion, which involved presentations and input from Hyperloop experts from industry and academia, the Council concluded that:

- The key technological foundations of Hyperloop are based on established technology and fundamentally sound; however, there will be extensive technical challenges to be overcome to enable them to work together at high speeds and ensure such a system could operate safety and securely.
- Specific key challenges for a UK Hyperloop system include emergency braking at high speed, social acceptance, and challenges in construction.
- The development of a UK Hyperloop network has the potential to stimulate economic development by substantially reducing journey times, enabling travel times of less than an hour for a majority of UK journeys.
- Due the UK's significant expertise in industry and academia in the foundation technology areas of Hyperloop, the UK has the ability to support the worldwide delivery of Hyperloop systems.
- Due to the technical challenges involved a UK Hyperloop system is at least a couple of decades away.

The Department welcomed this expert input on Hyperloop and the key points raised by the Council in this discussion have been used to create a position paper, which has been published and is available in Annex E of this report.

The minutes of this meeting are provided in Annex F.

4. Summary and Conclusions

The Council clearly continued to make a significant impact during its third year. Council members have provided advice on an extremely broad range of issues and the impact of the Council on individual policy areas is evident in both the Department and its wider Department agencies.

A number of clear examples can be cited where the Council has made an impact, such as the publishing of the two position papers on customer satisfaction and intelligent infrastructure, following on from Council meetings in 2015, the expertise provided for the Vehicles Emission Review and the advice provided for emerging technologies such as Hyperloop.

This year also saw the Council drive the consideration and awareness of using systems thinking within the Department to better deliver evidence needs, enabling the gathering of expertise from across the area and identifying ways to use this approach in transport. The Council also influenced the DfT's innovation agenda, providing valuable advice on both current innovation programs and how to maximise the impact of the DfT Innovation Challenge Fund.

Over the course of 2016, the visibility of the Council has increased with meetings between the Council's members and Ministers and Senior Officials from the Department. However, there remains some scope to build upon this to increase the Council's visibility within the Department and ensure that its skills and capabilities are always fully utilised to inform the Department's Science and Research needs.

Council members are always invited to bring key strategic Science and Engineering issues to the attention of the Department and provide strong challenge to the Department's Science and Technology work. There remains scope for additional experts to join from areas not currently represented within the SAC, ensuring that it will continue to provide comprehensive expertise for Science, Technology and Innovation to the Department.

Overall, the Science Advisory Council has continued to provide a valuable resource of strategic science and technology advice for the Department, building on the success of previous years.

Annex A: Biographies of Council Members 2016

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

Professor Lord Mair is the Sir Kirby Laing Professor of Civil Engineering and Head of Civil and Environmental Engineering at Cambridge University. He was Master of Jesus College 2001 to 2011 and Senior Vice-President of the Royal Academy of Engineering 2008 to 2011. He is Vice-President of the Institution of Civil Engineers.

Before he was appointed to a professorship at Cambridge in 1998 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's 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. He introduced the technique of compensation grouting to the UK; this was successfully used to protect Big Ben from movement due to construction of the adjacent Westminster Station and the technique has now been adopted worldwide. He is closely involved with Crossrail, Europe's largest civil engineering project, and is a member of its Engineering Expert Panel. He gave evidence to the House of Commons and House of Lords Select Committees in connection with the Crossrail Bill.

Professor Lord Mair also leads the Centre on Smart Infrastructure and Construction at Cambridge, involving the innovative use of the latest sensor technologies to monitor the behaviour of civil engineering infrastructure. He chaired the Royal Society/Royal Academy of Engineering report on shale gas for the government, published in 2012.

He was elected a Fellow of the Royal Society in 2007 and awarded the CBE in 2010 for services to Engineering. In October 2015 he was appointed an independent crossbencher in the House of Lords.

Professor Barry Clarke FICE

Barry Clarke, Past President of the Institution of Civil Engineers and Professor of Civil Engineering Geotechnics, is a founding Director of the Institute of Resilient Infrastructure at the University of Leeds. He is a Past President of the UK Engineering Professors Council; represents higher education on the Board of CITB ConstructionSkills, the training body for the UK construction industry; is chair of E4BE, a UK Construction Industry Council led body that focuses on the educational base of professionals working in the built environment; is a member of the Engineering Strategic Advisory Team of EPSRC, the research funding body for engineering research in the UK; and is Chairman of the Engineering Accreditation Board, a body that brings all the UK professional engineering bodies together to address the education of engineers.

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 is a member of the Independent Transport Commission and co-chairs the DfT's Joint Analysis Development Panel. He has carried out various advisory roles for the European Commission and for several national and city governments around the world. He is currently a Member of the CIHT Urban Design Panel, the London Commission for Roads and Streets, the Manchester Congestion Expert Reference Group and the Commission for Travel Demand.

He is the Scientific Co-ordinator of the EU 'CREATE' project, and has a wide range of transport research and teaching interests, covering both analytical methods and policy. These include:

- 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
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Professor Paul Newman FREng FIET FIEEE

Paul Newman is the BP Professor of Information Engineering at the University of Oxford and an EPSRC Leadership Fellow. He heads the Mobile Robotics Group within the Department of Engineering Science which enjoys a world leading reputation in mobile autonomy - developing machines and robots which map, navigate through, and understand their environments. His focus lies on pushing the boundaries of navigation and autonomy techniques in terms of both endurance and scale.

The Mobile Robotics Group has developed a keen focus on intelligent transport for example the RobotCar and enjoys collaborations with many industrial partners which provide exploitation opportunities to drive the research. In 2014 he founded Oxbotica - a spinout company focussed on Robotics and Autonomous Systems - and was elected fellow of the Royal Academy of Engineering with a citation for outstanding contributions to robot navigation.

He obtained an MEng in Engineering Science from Oxford University, Balliol College in 1995. He then undertook a PhD in autonomous navigation at the Australian Center for Field Robotics, University of Sydney, Australia. In 1999 he returned to the UK to work in the commercial sub-sea navigation industry. The navigation software he wrote then was used to repair the Deep Sea Horizon leak in 2010.

In late 2000 he joined the Department of Ocean Engineering at MIT where as a post-doc and later a research scientist, he worked on algorithms and software for robust autonomous navigation for both land and sub-sea agents. In early 2003 he returned to Oxford as a departmental lecturer in Engineering Science before being appointed to a University Lectureship in Information Engineering and becoming a Fellow of New College in 2005, Professor of Engineering Science in 2010 and BP Professor of Information Engineering and Fellow of Keble College in 2012.

Paul Stein FREng

Paul joined Rolls-Royce in 2010 as Chief Scientific Officer and for two years acted as the Engineering and Technology Director for the Company's Nuclear business in addition to his Chief Scientific Officer responsibilities. His most recent role was Director of Research & Technology, accountable for the company's global investment in R&T, as well as fostering innovation and promoting and sustaining specialist engineering talent.

In his previous career, Paul became the Director General, Science and Technology at the Ministry of Defence in 2006, responsible for the technical direction, prioritisation and out-sourcing of the UK's £500m annual investment in Defence S&T.

In 1996 he was appointed Managing Director Roke Manor Research, at that time owned by Siemens. Its most famous commercially successful innovation is 'Hawk-Eye', the ball sports tracking system used for line call verification in tennis. In 2003 Paul was appointed to the Siemens UK Executive Management Board leading technology and contributing to business strategy.

Paul started his career at Philips Research Laboratories in Redhill, Surrey developing technology and systems engineering techniques for early generation analogue cellular phone systems, then moving into the development of military communications systems and then progressing into business development roles.

Paul graduated in Electrical and Electronic Engineering from King's College London in 1978. He is a Fellow of the Royal Academy of Engineering, a Fellow of the Royal Aeronautical Society and a Fellow of the Institution of Engineering and Technology.

He is married with two children and two step-children, and lives in both Harrow and Ashbourne, Derbyshire.

Professor Ricardo Martinez-Botas IMechE

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 to 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 contributions to this area, centre on the application of unsteady fluid mechanics, instrumentation development and computational methods. The work has attracted support not only from government agencies but also from industry. His group has become a recognised centre of turbocharger turbine aerodynamics, and more particularly in the application experimental methods and one dimensional calculation procedures.

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

He is the current chair UK University Internal Combustion Engines Group (UnICEG) and he is also vice-Chair of the American Society of Mechanical Engineers (ASME) Turbomachinery Committee. He is a visiting professor in the University Teknologi of Malaysia and at the Nanyang Technical University in Singapore. He has published over 85 journal papers. He is Associate Editor of the ASME Journal of Turbomachinery and the IMechE Journal of Mechanical Engineering Science.

Sue Duncan

Sue Duncan is an independent research consultant, with over thirty years' experience working in the public sector, at the centre of government in the Cabinet Office and Treasury, and in social policy departments, such as the Department for Work and Pensions, and Communities and Local Government.

While at the Cabinet Office, she worked in the Prime Minister's Strategy Unit and was Director of Policy Studies in the Centre for Management and Policy Studies, where she was responsible for good practice in policy making, research and evaluation and for evidence-based policy making. For much of her civil service career she was in the Government Social Research service

(GSR), where she worked closely with senior civil servants and Ministers, providing research based advice and policy analysis to inform government decision making. Her career in government culminated in her appointment as the first ever Chief Government Social Researcher, responsible for the thousand or so social researchers working across government.

She has written and lectured widely on policy, research, research utilisation and evidence-based policy making. Publications include a book on the policy process under New Labour (Bochel & Duncan 2007) *Making policy in theory and practice* (Bristol: Policy Press), and articles in peer reviewed journals. She is a social scientist and has a BSc (Hons) from the University of Bath and an MA from the University of Sussex. She was a Visiting Professor at the University of Bristol and is now a Visiting Professor at the University of Lincoln; a Fellow of the Market Research Society; an Academician of the Academy of Social Sciences; a member of the Social Research Association; an Honorary Fellow of Cardiff University and an Honorary Doctor of the University of Bath. She is also President of the Social Policy Association; a Trustee of the Stroke Association and Chair of its Research Strategy Committee.

Professor Eddie Wilson

Eddie Wilson is Chair in Intelligent Transport Systems at the University of Bristol and head of the department of Engineering Mathematics. He is an applied mathematician and mathematical and computational modeller by training, with interests across a very wide range of application domains, but with a particular focus on transport; he has worked in highway traffic modelling. An especial interest has been on mathematics applied directly to industrial problem solving.

Work of direct interest to the DfT has previously involved advice to a DfT-sponsored project on the use of mobile phone data in transport models (delivered via the Transport Systems Catapult), and an EPSRC project on using MOT data to estimate patterns in national mileage.

Annex B: Terms of Reference for DfT Science Advisory Council

1. Aim of SAC

The SAC's primary aim is provide independent scientific and technical advice to DfT.

The provision of independent scientific and technical advice by the SAC will help to assist the DfT CSA to assure the quality and appropriateness of the Department's use of Science and Technology (S&T).

2. SAC Objectives

The objectives of the council are:

i. To advise the department on its systems, capability and processes for obtaining (S&T) advice that is fit for Departmental needs;

ii. To review the Department's strategic S&T priorities;

iii. To comment on key S&T risks, and contribute to horizon scanning capability;

iv. To reinforce links to national and international research community enabling DfT to get access to the best evidence;

v. To respond to ad-hoc requests for advice to support policy, where appropriate.

3. Responsibilities of the SAC Ad Hoc Members

i. Members are expected to follow the spirit of by the seven principles of public life (Nolan Principles).

ii. SAC members and the Chair should take note of the GCSA's *Guidelines on the Use of Science and Engineering Advice in Policy Making* and the GCSA's *Principles of Scientific Advice to Government* (details below).

http://www.bis.gov.uk/assets/goscience/docs/g/10-669-gcsa-guidelines-scientific-engineering-advice-policy-making.pdf

http://www.bis.gov.uk/go-science/principles-of-scientific-advice-to-government

iii. These papers will help the SAC to understand how science advice is taken up with departmental officials. Any issues should be discussed with the SAC Secretariat.

iv. Members should ensure they understand why they are being appointed to the SAC and in what capacity.

v. All members should share in the general responsibility to consider the wider context in which their expertise is deployed.

vi. All members are responsible for ensuring the independence, objectivity and impartiality of the SAC; individuals appointed to the SAC should not act as representatives for their particular profession, employer or interest group, and have the duty to act in the public interest.

vii. Any changes to the role/function of individual members on the SAC must be agreed with the Chair and DfT CSA.

viii. Members' role on the SAC should not be circumscribed by the expertise or perspectives he/she was asked to bring to the Group. Members should regard themselves as free and encouraged to question and comment on the information provided or the views expressed by any of the other members; notwithstanding that the views or information do not relate to their own area of expertise.

ix. Members can raise any concerns in regard to the SAC with the Chair or SAC Secretariat.

4. SAC Ways of Working

i. Declaration of Interests must be provided and signed by all SAC members and updated as appropriate and as circumstances change. The Register will be held by DfT only. Any issues should be discussed with the SAC Secretariat.

ii. SAC members generously provide their time and expertise in-kind, no honorarium is provided. DfT will reimburse all reasonable travel and incidental expense. In compliance with HMG guidelines, no first class travel can be undertaken for DfT business.

Seven Principles of Public Life '*Nolan Principles'*

1. Selflessness

Holders of public office should act solely in terms of the public interest. They should not do so in order to gain financial or other benefits for themselves, their family or their friends.

2. Integrity

Holders of public office should not place themselves under any financial or other obligation to outside individuals or organisations that might seek to influence them in the performance of their official duties.

3. Objectivity

In carrying out public business, including making public appointments, awarding contracts, or recommending individuals for rewards and benefits, holders of public office should make choices on merit.

4. Accountability

Holders of public office are accountable for their decisions and actions to the public and must submit themselves to whatever scrutiny is appropriate to their office.

5. Openness

Holders of public office should be as open as possible about all the decisions and actions that they take. They should give reasons for their decisions and restrict information only when the wider public interest clearly demands.

6. Honesty

Holders of public office have a duty to declare any private interests relating to their public duties and to take steps to resolve any conflicts arising in a way that protects the public interest.

7. Leadership

Holders of public office should promote and support these principles by leadership and example.

Declaration and Register of Interests for DfT SAC Members

General Information

SAC members (including the Chair) must declare any interests which may be relevant and material to the work which they will be undertaking whilst serving on DfT's SAC.

Interests which should be regarded as "relevant and material" can include:

1. Directorships, including non-executive directorships held in private companies or PLCs (with the exception of those of dormant companies).

2. Ownership or part-ownership of private companies, businesses or consultancies likely or possibly seeking to do business with the DfT.

3. Majority or controlling shareholdings in organisations likely or possibly seeking to do business with the DfT.

4. Any connection with a voluntary or other body contracting for DfT services.

5. Any professional or personal connection or involvement with DfT employees.

Annex C: Systems Thinking Meeting Minutes

Department for Transport

DfT Science Advisory Council
09:30 – 16:30 Wednesday 24th February 2016
Department for Transport, Room H1, 33 Horseferry Road, London SW1P 4DR

SAC Members
Prof Lord Mair, Chair
Prof Peter Jones
Prof Ricardo Martinez-Botas
Prof Barry Clarke
Prof Paul Newman
Ms Sue Duncan
Prof Eddie Wilson

Apologies
Mr Paul Stein

Internal Attendees
Prof Phil Blythe, Chief Scientific Adviser, DfT
Steven Finch, Acting Chief Scientist and DfT Deputy Chief Scientific Adviser
Deirdre O'Reilly, Head of Social and Behavioural Research and Evaluation, DfT
Kylie Lovell, Principal Research Officer, Social and Behavioural Research and Evaluation, DfT
Andrew Scott, Senior Research Officer, Social and Behavioural Research and Evaluation, DfT
Neil Ebenezer, Head of Science and Research Division, DfT
Richard Bruce, Head of the Office for Low Emission Vehicles, Office for Low Emission Vehicles (OLEV)
Michael Clark, Deputy Director, International Aviation Safety & Environment
Robin Groth, Deputy Director, Rail Technical, International & Safety
Sir Alan Massey, Chief Executive, Maritime and Coastguard Agency
Simon Connick, Deputy Head of Unit, Strategy Unit

Fiammetta Gordon, Head of Local Economics Division
Tom Salter, Technical Oversight Manager, Transport Security Co-ordination & Operational Response
Katie Gronow, Operational Research Project Manager, In House Analytical Consultancy
Lizzie Baggott, Operational Research Project Manager, In House Analytical Consultancy
Catherine Lovell, Environmental Strategy

External Attendees
Patrick Godfrey, University of Bristol
Brian S Collins, University College London
Hillary Sillitto, University of Bristol
Damitha Adikaari, Department of Energy & Climate Change
Andy Boston, Energy Research Partnership
Sandy Yatteau, Department of Engineering, University of Cambridge
Rob Furlong, Knowledge Transfer Network

DfT Secretariat
Manny Chung
Clemence Cavoli
Claire Rees

1. **Welcome, Introduction and updates**

The Chair welcomed SAC members and guests and set out the agenda for the day. The Chair invited the SAC secretariat to provide an update on the actions from the last meeting. The minutes and actions from the previous meeting on 07 December 2015 were agreed without amendments. It was mentioned that:

- The Energy Research Partnership project on 'Energy Options for Transport' will deliver their final report in the next month and this will be shared with Council members. **ACTION 1**
- The final reports from the two Ad Hoc Committees will be discussed with the Permanent Secretary on April 28th. **ACTION 2**
- Government website should host all the minutes from each SAC meeting. **ACTION 3**
- A potential joint SAC meeting with other Councils from other government departments should be explored. **ACTION 4**

2. **Ad Hoc Committee - Intelligent Infrastructure and Condition Monitoring**

The Chair provided an overview of the final report on Condition Monitoring and Intelligent Infrastructure.

It was mentioned that there are numerous challenges facing existing infrastructure in the UK today which have implications for risk and resilience and asset management. Smart infrastructure can play a role in addressing these, however, four scales of interrelated challenges were mentioned that need to be thought of when considering intelligent infrastructure:

- sensors and data collection
- data analysis
- building information monitoring
- cities and infrastructure systems.

Although the definition of value can be interpreted in many ways, it was noted that value in infrastructure can be thought of as infrastructure continuing to perform its function – at the required quality – at an acceptable level of risk – incurring an acceptable level of expense.

The traditional approach to value is cost based, i.e. minimal investment in building infrastructure without consideration of performance during its life-time. Value-based is recommended to maximise the performance and minimise the risk and this is where sensors and smart infrastructure can deliver value.

The risks faced by our infrastructure, and ones leading to accelerating degradation, were noted as:

- Increased asset loading;
- Climate change;
- Ageing.

Considering these risk, the key drivers behind investing in Smart Infrastructure were considered to be:

- Making most of what we have;
- Deliver savings;
- Keep pace with EU;
- Identifying priorities for maintenance work;
- Controlling costs and carbon footprint;
- Whole life costs;
- Less disruption.

In taking this forward, it was suggested that government should give some thought to incentivizing and driving change whilst considering:-

- An audit of our current assets - do we know what we have?
- New standards - could provide confidence for investment
- Guidelines for data storage - Data sharing, who owns the data and how is it shared?
- Skills deficit - New skills are needed to be more aware of all of the technologies

A discussion of the report amongst members followed, where by it was mentioned that:-

- European countries are significantly better at this than the UK e.g. condition monitoring and intelligent infrastructure in the rail sector in France is more advanced than the UK as a result of more investment;
- There is a disconnect between national and regional thinking in relation to intelligent infrastructure in the field of transport
- The UK takes more of an economics-based approach, whilst appraisal in other European countries is done differently; the vision is often prioritized
- Tendering of procurement contracts should be more innovative, where requirements related to sensors, intelligent infrastructure and whole life costs should be explicitly stated. However, it was noted that appraisal of projects does not allow for this at present and procedures dictated by the Green Book should be looked at with the Government Economic Service; **RECOMMENDATION 1**
- There is a need to better prepare the next generation of data scientists. Further skills are needed. **RECOMMENDATION 2**

3. Ministerial Meeting

The Minister responsible for technology, Andrew Jones MP, was invited to the Council meeting to learn more about the Council's activities and share his thoughts on science and technology.

The Council members introduced themselves to the Minister and the Chair provided an introduction to the previous discussion on condition monitoring and intelligent infrastructure and the potential value of it. It was highlighted that:-

- Better use of technology can enable optimisation of assets;

- A national audit of assets is required to understand what we have; **RECOMMENDATION 3**
- New standards are needed for sensing and monitoring and should improve effectiveness; **RECOMMENDATION 4**
- Guidelines for data ownership and storage are required; **RECOMMENDATION 5**
- Government procurement guidelines need to better accommodate innovation;
- New generation of engineers need to be better trained.

The Minister raised the point of the rapid pace with which technology is changing e.g. autonomous vehicles and questioned the pace of uptake of this new technology. It was accepted that uptake of technology can be slow, and likely to take a number of years to become mainstream and for benefits to be realised. However, how can that be accelerated? Particularly, how can successes regarding innovation be better disseminated to help drive the uptake of technology whilst addressing concerns such as data security?

Council members highlighted that there is a need for improved consultation with stakeholders and the public at the start of major projects. It was mentioned that customer benefits should be further highlighted when building new infrastructures. Explaining whole life costs upfront could help with accepting a greater upfront initial cost of a project. Members highlighted that a retrospective look at how computers revolutionized society could help us learn how data will be adopted as there are very strong similarities. **RECOMMENDATION 6**

4. Ad-Hoc Committee – Customer Satisfaction Measures across Transport

The Chair invited Kylie Lovell, Principal Research Officer, Social and Behavioural Research and Evaluation, DfT and Andrew Scott, Senior Research Officer, Social and Behavioural Research and Evaluation, DfT to present and overview of this project. It was mentioned that:

- Following recommendations made by Council members, the Social and Behavioral Unit undertook a scoping study to investigate how customer satisfaction is measured by different transport operators and across modes, in particular rail and roads;
- The scoping study identified nine themes frequently measured, including overall satisfaction, information and facilities;
- However, the study noted that all the themes are not automatically addressed by customer satisfaction surveys across modes;
- It was highlighted that road users consider their journey holistically, they want to get from A to B efficiently, therefore the success of the entire journey should be evaluated, not its component parts. Furthermore, road users do not distinguish between the strategic road network and local roads. The focus should be on journey experience, not road infrastructure. Finally, it was mentioned that satisfaction depends on how well expectations are met– road users expect to be able to complete the journey as planned; disruption leads to loss of control.

Council members commented that:-

- The Department should look across all modes for a seamless journey;
- Coordination between surveys (across modes and operators) is needed as it is often fragmented, the DfT is in a position to ensure customer satisfaction compatibility across modes;
- The objectives of customer satisfaction should be better defined, a strategic direction should be established across modes;
- Customer satisfaction is very important to ensure the quality of what is being offered and can be used as an indicator to identify where problems arise; It is key for Ministers;
- Low level of satisfaction could impact investment, hence the need to have robust satisfaction measures;
- The Department:
    - Should identify where it could standardise the methods used to measure customer satisfaction across modes and establish strategic objectives ;
        - The DfT could commission a piece of work to look at cross-modal opportunities;
    - Could initiate a discussion between key stakeholders across modes to discuss the issues mentioned above. **RECOMMENDATION 7**

5. Potential Topic for next SAC

Topics for future meetings were briefly discussed. The following list will be considered: **ACTION 5**

- Air quality;
- Data and information connectivity considering cyber security (related to autonomous vehicles for instance);
- National Transport Model;
- Logistics and the impact of it on the road network;
- Different methods used in forecasting traffic across modes
- Single Departmental Plan.

6. Systems Thinking Workshop

The afternoon of the Council meeting involved a workshop on Systems Thinking, and was Chaired by Professor Eddie Wilson.

The Chair invited Professor Patrick Godfrey to provide an overview of Systems Thinking. It was highlighted that:

- '***Systems Thinking*** *is a way of thinking used to address complex and uncertain real world problems. It recognises that the world is a set of highly interconnected technical and social entities which are hierarchically organised producing emergent behaviour.' INCOSE UK Z7 Guide*
- Systems thinking is an engineering habit of mind;
- It is key to addressing problems and useful in dealing with uncertainties;

- Understanding the relationships between the parts is key to understanding the performance of the whole.

This was followed by Professor Barry Clarke presenting a case study on Systems Thinking applied to transport and energy. Applications of systems thinking are understood and practiced but it is not a widely held view given the tendency to operate in silos. The education of built environment professionals is an example of this silo approach though in practice they operate in multi-disciplinary teams. It is also known that systems are interdependent but those interdependencies are often not fully appreciated until a failure of a component of one system impacts on other systems. An example of this is the systems managed by the Environment Agency, Local Authorities and water companies covering coastal and flood protection impacting on transport systems. It is also necessary to appreciate that not all systems are fully understood. The interdependency of transport and energy is the example being used in the workshop. This brief presentation focuses on three elements – interdependency, place and space – using examples to highlight some aspects of systems as an introduction to the workshop. It was mentioned that:

- There are a multitude of systems interacting in numerous ways;
- Most infrastructure systems are considered in two dimensions; there is a need to develop a 3D infrastructure that includes air, surface and underground;
- National infrastructure thinking focuses on projects and networks whereas local infrastructure thinking focuses on place, which is more appropriate;
- Systems thinking can help improve resilience of interconnected systems;
- Transport corridors are 3D multi-functional spaces.

The In-House Analytical Consultancy (IHAC) team then provided a demonstration of a Systems Thinking tool used within the Department. Attendees were encouraged to consider the interdependencies and interconnections of transport and energy, taking the total miles travelled by the use of electric powered transport as an example. The causes (drivers for the increase) and effects (the effect of increasing travel by this method) of this were discussed and mapped out (Annex A).

A discussion followed these presentations, where attendees were invited to provide their thoughts on Systems Thinking and how it could play a greater role in DfT decision making. Comments made included:-

- Systems Thinking needs to be further embedded and encouraged, for this to happen a culture change is needed within the Department; **RECOMMENDATION 8**
- Corporate knowledge needs to be better managed, and treated as an asset; **RECOMMENDATION 9**
- There are some organizations, such as the National Infrastructure Commission that take a more holistic view. Systems thinking is also used across governments, the Office for Low Emission Vehicles is another good example;

- There are a number of constraints within the civil service that make Systems Thinking challenging. These are related to regulatory, accounting, assessment and Bill making structures, e.g. processes dictated by the Green Book;
- Barriers to more strategic longer term thinking need to be highlighted. An example of assessment being more money-based rather than value-based was given where the business plan for Birmingham New Street station did not fully consider passengers. A systems view would have been helpful here. The turnover of staff can sometime be a barrier to Systems Thinking as people are not in post long enough to apply this approach;
- However, processes are in place for justified reasons, such as controlling government spending;
- Establishing a 'space' away from the structures is needed to think in a systematic way

Whilst considering the points raised during the discussion, the Council made several recommendations for the next steps in embedding Systems Thinking in the Department, including:-

- Creating a Systems Thinking champion in the Department; **RECOMMENDATION 10**
- A network for Systems Thinking that people in the Department could join to learn more through:-
    - Training and/or learning material of 'what, why and how' of Systems Thinking;
    - Talks on Systems Thinking; **ACTION 6**
- A demonstration of where Systems Thinking has been applied and worked well, as well as a recent case study:-
    - A project on aviation security due to take place soon was offered as a test case;
    - Government work on drones was also offered. **ACTION 7**
- A slide pack summarizing the workshop outputs should be shared amongst senior decision makers **ACTION 8**
- The National Infrastructure Commission should be engaged

The Science Advisory Council Chair closed the session, commenting that:-

- A demonstrator project on drones or aviation security will be really good in showing the value of Systems Thinking and the Council are more than happy to assist in applying the techniques available;
- The slides presented will be shared amongst attendees; **ACTION 9**
- Unintended consequences can be foreseen if systems thinking approach is used.

7. AOB

- The Council members were reminded to provide comments on the annual report to the secretariat

- The Energy Research Partnership will be holding a workshop on 21st April on the Energy Options for Transport project;
- The next SAC meeting will be on 29th April and will discuss Air Quality.

Recommendations Log

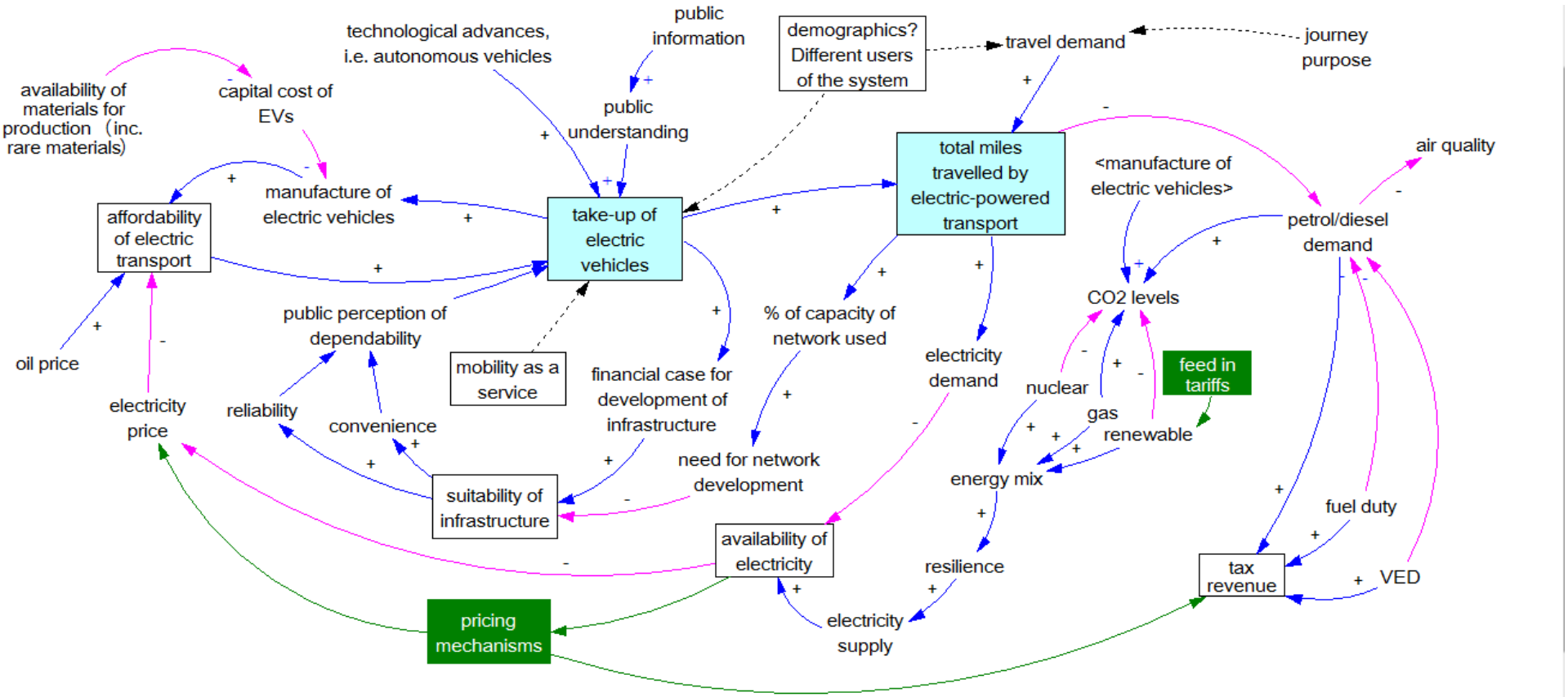
No	Recommendations to the DfT
1	Tendering of procurement contracts should include requirements related to sensors, intelligent infrastructure and whole life costs. Procedures dictated by the Green Book should be looked at with the Government Economic Service to address limitations with appraisal
2	Further skills are needed to better prepare the next generation of data scientists
3	A national audit of assets is required to understand what we have
4	New standards are needed for sensing and monitoring
5	Guidelines for data ownership and storage are required
6	The public should be better consulted at the start of major infrastructure projects. Customer benefits should be highlighted and explanation on whole life costs given, which could help with accepting greater upfront costs
7	The DfT should identify where it could standardise the methods used to measure customer satisfaction across modes and establish strategic objectives ; ➢ The DfT could commission a piece of work to look at cross-modal opportunities; Could initiate a discussion between key stakeholders across modes to discuss the issues mentioned above.
8	Systems Thinking needs to be further embedded and encouraged, for this to happen a culture change is needed within the Department
9	Corporate knowledge needs to be better managed, and treated as an asset
10	There is a need to create a Systems Thinking champion in the Department

Action Log

Action No	Action	Owner	Due Date
1	ERP to share their report with Council members	ERP	Asap
2	The final reports from the two Ad Hoc Committees to be discussed with the Permanent Secretary.	SAC	April 28th
3	Government website should host all the minutes from each SAC meeting	SAC Secretariat	Asap

4	A potential joint SAC meeting with other Councils from other government departments should be explored	SAC & SAC Secretariat	2016
5	Topics for future meetings include: • Air quality; • Data and information connectivity considering cyber security (related to autonomous vehicles for instance); • National Transport Model; • Logistics and the impact of it on the road network; • Different methods used in forecasting traffic across modes • Single Departmental Plan.	SAC & SAC Secretariat	2016-2017
6	• Establish a network for Systems Thinking that people in the Department could join to learn more through:- o Training and/or learning material of 'what, why and how' of Systems Thinking; o Talks on Systems Thinking;	OP, DfT, Science and Research Team	Asap
7	• Provide a demonstration of where Systems Thinking has been applied and worked well in DfT: o A project on aviation security due to take place soon, and/or o Government work on drones	OP, DfT, Science and Research Team	Asap
8	• A slide pack summarising the workshop outputs should be shared amongst senior decision makers	SAC Secretariat	Asap
9	The slides presented at the workshop to be shared amongst attendees	SAC Secretariat	Asap

ANNEX A


availability of materials for production (inc. rare materials)
capital cost of EVs
technological advances, i.e. autonomous vehicles
public information
public understanding
demographics? Different users of the system
travel demand
journey purpose
total miles travelled by electric-powered transport
<manufacture of electric vehicles>
air quality
petrol/diesel demand
affordability of electric transport
manufacture of electric vehicles
take-up of electric vehicles
CO2 levels
oil price
public perception of dependability
mobility as a service
financial case for development of infrastructure
% of capacity of network used
electricity demand
nuclear
gas
renewable
feed in tariffs
electricity price
reliability
convenience
suitability of infrastructure
need for network development
energy mix
fuel duty
availability of electricity
resilience
tax revenue
VED
pricing mechanisms
electricity supply

Annex D: Innovation Meeting Minutes

Department for Transport

DfT Science Advisory Council
09:00 – 15:10 Friday 29th April 2016
Department for Transport, Room H1,
33 Horseferry Road, London SW1P 4DR

SAC Members
Professor Lord (Robert) Mair, Chair
Professor Peter Jones
Professor Ricardo Martinez-Botas
Professor Barry Clarke
Professor Eddie Wilson
Paul Stein

Apologies
Professor Paul Newman
Sue Duncan

SAC Secretariat
Manny Chung
Clemence Cavoli
Claire Rees

DfT Officials
Professor Phil Blythe, DfT Chief Scientific Advisor
Deirdre O'Reilly, Head of Social and Behavioural Research
Iarla Kilbane-Dawe, Acting Head Partnerships and Engagement
Ian Yarnold, Head International Vehicle Standards
Duncan Kay, Head International Vehicle Standards Environment team
Neil Ebenezer, Head Science and Research
Scott Stevenson, Better Regulation and Transposition team
Chris Brown, Rail Research Programme Manager
Matt Coleman, Science and Research division

OGD Officials
Stuart Barthropp, BIS

External Speakers
William Reddaway, Innovation Programme Manager, Crossrail

Kevin Turpin, Principal Consultant, TRL

External Experts
Achille Fonzone, Deputy Director, Transport Research Institute, Napier University
Tessa Darley, Knowledge Transfer Network (KTN)
Rob Furlong, KTN
Paul Zanelli, Transport Systems Catapult
Roland Meister, Innovate UK
Ian Meikle, Innovate UK
Tristan Smith, University College London

Welcome, Introductions and Updates

1.1. The Chair welcomed the Council members, officials and guests and set out the agenda for the day

1.2. The Chair invited the SAC Secretariat, to provide and update on the actions from the last meeting.

1.3. The minutes and actions from the previous meeting on 24 February 2016 were agreed without amendments.

1.4. The following items were discussed:

- The Energy Research Partnership (ERP) final report. The key conclusion from the report is that there is no effective decarbonisation path for heavy good vehicles. Ricardo Martinez-Botas met twice with ERP representatives to discuss the report.
- The two ad hoc group reports (**Intelligent Infrastructure and Condition Monitoring and Customer Satisfaction**) will be incorporated into the SAC annual report.
- A high impact summary of the SAC minutes will be produced to disseminate the outputs of the SAC outside of the DfT. The SAC were shown a draft of the new format which will be published as soon as possible given Purdah restrictions.
- Potential joint SAC meeting - all agreed that there has to be a common need for the meeting from both SACs. A joint SAC on Air Quality has been investigated but at the moment a common output has not been identified. The Secretariat will maintain a watching brief for future opportunities. **ACTION 1**
- Future topics - Artificial Intelligence should be added to the list. The next SAC meeting will focus on Cyber Security and will include external experts. **ACTION 2**
- Draft Systems Thinking slides were produced and used to initiate further ST activity in DfT. **ACTION 3**

Ad Hoc Groups

1.5. The Council has been tasked with taking forward two specific areas of interest in the form of task and finish groups and produce a position statement on the subjects. The two subjects are **Intelligent Infrastructure & Condition Monitoring** and **Customer Satisfaction.** The final report from the condition monitoring project was discussed with the Permanent Secretary at the working dinner for the Council, Directors General (DGs) and Non-Exec Directors (NEDs) on April 28th.

Intelligent Infrastructure & Condition Monitoring

1.6. The Chair provided an overview of the meeting held on 28th April with the Permanent Secretary, DGs and NEDs. The next steps for dissemination of the report were discussed. Contractors, consultants and Agencies are the bodies that will be interested in the report. A suggestion was to disseminate the report through professional bodies, such as the Institution of Civil Engineers who operate nationally and regionally and the Chartered Institution of Highways and Transportation. **ACTION 4**

1.7. The DfT is able to communicate with Highways England and other relevant government agencies to disseminate the report as widely as possible. Prof Lord Mair suggested meeting with the relevant professional bodies to discuss dissemination of the report. **ACTION 5.**

1.8. It was also discussed during the evening dinner that there is a need for a change of culture at the DfT and an improvement of procurement processes. Innovation funds could support pilot projects related to condition monitoring and intelligent infrastructure.

1.9. Observations in the discussion included:

- this is very much an opportunity to demonstrate the use of smart solutions,
- the impact and benefits, need to show a monetary value, hence the need for demonstrative pilots
- is this an opportunity for cross modal knowledge transfer, for example aircraft are heavily monitored can the same principle be applied to railway stock, roads and bridges?
- in the world of businesses cases, how do we present this as a worthwhile 'in between step'?
- this is shown by a classical cost benefit, small investment but worth it as it may also capture the untended consequences. It would be useful to find existing examples where this has been the case.

Customer Satisfaction

1.10. The Chair invited the Head of Social and Behavioural Research**,** to provide an update on the scoping paper to map the range of customer satisfaction/experience measures used across transport modes. This paper has been produced in collaboration with Sue Duncan and Prof Peter Jones.

1.11. 8 recommendations were made but the key ones are:

- Consistency and coordination within the Government and other agencies in how satisfaction is measured.
- Harmonised measurements should be established between modes.
- Rigor and quality should be further monitored.
- Consistency of research method and design.

1.12. Knowledge management needs to be addressed. Collaboration between Transport Focus, Government Agencies, Government and other stakeholders. (National Travel Survey is piloting a project asking people to rate their journey across different modes).

1.13. A question bank has been produced by the Social and Behavioural Research team and will be published soon. These questions might be used by different institutions

and bodies that are measuring satisfaction across modes. Collaborations between different institutions are key.

1.14. Deirdre to provide a summary of the key recommendations in a revised document to be circulated to members. **ACTION 6.**

Evidence and Research Summaries

1.15. The Chair invited the Acting Head, Partnerships and Engagement, to provide an overview of the Evidence Research Summaries (ERS).

1.16. The aim is to get more value out of the research the DfT undertakes. The budget last year was just under £80 million. Highways England has £100 million to spend on Innovation. £30 million is spent on rail and £20 million on ULEVs.

1.17. The way to improve research is to better understand what evidence is out there and to commission more research. A statement of needs will be developed by the DfT. A large focus is on Social Research.

1.18. The ERS' have been a tool to better understand what research activities are taking place within the DfT.

1.19. The main question to the SAC is:

a. What are the next steps?

b. How to take the research to academia and other experts stakeholders?

c. How to build links between the Government and research groups?

1.20. SAC response:

- EPSRC does not have mission programme on transport and mobility. Transport needs to have its own independent research programme. This could be achieved during the forthcoming restructure.
- The CSA has been in dialogue with the research councils on this matter. There is a great amount of work being done on transport projects but there is a great deal of mis-categorisation of grants.
- However, EPSRC's mission is to deliver impact. Also, it can be difficult to obtain cross council funding where research affects more than one area.
- Statements of needs should leave room for flexibility and ad hoc responsiveness to contingency.
- Social, systems and mobility should be given more importance within EPSRC. We need to influence the strategy team.
- Establishing further links between academia and the Government is needed. Consider 'challenge days' where policy makers can meet academics or even consider holding sandpits. **RECOMMENDATION 1**
- Secondments into the DfT could be considered. From outside the department is difficult to navigate, but S&R could be used as the conduit. The same problems applies with other departments and finding the conduits is difficult.
- Funding should be offered to academics to get them to participate, interesting questions and problems to solve to motivate academics.
- DfT should prepare some PowerPoint slides explaining what research needs are in the DfT. This would be extremely helpful, so that academics have a better

understanding and can engage more easily. To gain interest there must be a good problem to solve. **RECOMMENDATION 2**

- 'Centres for Excellence' working on a five year contract is an effective model. Pick a chosen selection of key university groups and offer the work. However this may pose difficult with procurement rules.
- Establish longer than one year funding programmes. For instance, Fellowship Schemes undertaken in collaboration with the Royal Academy would be an effective way of targeting early career researchers. The DfT could support those schemes. Five-year funding principle of research. **RECOMMENDATION 3**.
- The SAC could provide the foreword for the statement of needs or indeed to a joint one with the Perm Sec or a minister. **ACTION 7**
- The SAC agreed that they would provide input into a future research strategy. Reviewing the HS2 research programme could be the first step in collaboration.
- Research commissioned by the DfT, should be open to the public and the DfT website should be updated to provide a dissemination route for research. **ACTION 8**

Vehicle Emissions

Vehicle Emissions Testing Programme

1.21. The Chair invited Ian Yarnold, **Head International Vehicle Standards,** to give a background introduction to the programme and an update on the report of the Government's response. The final report was published on Tuesday 26th April 2016, the German and French Governments published their responses on the following day.

1.22. The Chair then invited Vehicle emissions testing programme overview by Duncan Kay**,** Head of the International Vehicle Standards Environment team to present the detail of the testing programme**.**

1.23. The aim of the programme was to improve understanding of the real world emissions performance of vehicles. 37 diesel vehicles representative of a high proportion (given the use of engines across platforms) of diesel vehicles in the UK were selected and vehicles were sourced independently. The testing was conducted in the presence of engineers from the Vehicle Certification Agency.

1.24. Professor Ricardo Martinez-Botas was in charge of the quality checks.

1.25. In summary, a lab test was conducted according to the legislative procedure; the lab test was then reversed (high speed and urban) to establish if a defeat device had been fitted; an 'on road' test was conducted to compare hot tests (noting that there were variances in the ambient temperature).

1.26. The On Board Diagnostics (OBD) ports were not used at all, to reduce the likelihood of recognition of interrogation and the defeat device not activated.

1.27. Positive results included:

- other than the vehicles known to have defeat device fitted, no others were found
- although the Euro 5 vehicles demonstrated that the 'on road' tests had considerably different results to the lab test the Euro 6 engines were 70% better

1.28. The SAC discussed what needs to be considered going forward - the quantification of the variables: weight, temperature, flexibility of the dynamometer, the driver and

tyre pressures. Driver behaviour cannot be generalised and needs to be considered by make and model.

1.29. A lot more evidence from Portable Emissions Measurement Systems (PEMS) testing, however this test method has only been available for the past few years and is still expensive, there needs to be a lower cost solution. This evidence is needed urgently.

1.30. 2025 is the realistic timeline for any new test procedure, 2 years for research, 3 years for negotiation and 3 years lead time.

1.31. Clarity is needed on the link to health issues, but the issue is wider than car emissions. There should be consideration of trucks, buses, aviation and ground generators.

Vehicle Emissions Evidence Review

1.32. The Science and Research Division has been commissioned by the Government Chief Scientific Advisor, Sir Mark Walport, to lead a project on looking at whether current vehicle emissions testing regimes are fit for purpose and review the evidence base that supports them.

1.33. The Chair invited Iarla Kilbane-Dawe**, Acting Head Partnerships and Engagement**, to provide an update on the scoping paper describing the vehicle emissions review. It was noted that:

- There is limited peered reviewed evidence on the topic
- Some manufacturers have known how to solve the NOx problem for a long time. The US NOx standards is stricter.
- Transient emissions are important because they reflect real world driving, there is a lack of understanding on this issue. The equipment has only been available over the last few years and therefore has not been widely used.
- Little work done on driver behaviour.
- There is a need for further PEMS equipment to test real world emissions
- Strategic Research Action: further measurements of vehicles on road need to be established. This evidence gap needs to be addressed, gaps should be identified.
- DfT could drive further real world emissions driving tests.
- Congestion Charging could take into account the test results to limit access to the city to the most polluting vehicles. But the current evidence is not sufficient. More needs to be done.
- Government resources and funding are limited to gather further evidence.

1.34. SAC members will give their views on the draft research paper highlighting the second phase of the research which has to be submitted to Sir Mark Walport. By the end of next week SAC members are invited to make comments on the research agenda **ACTION 9**.

1.35. A Systems Thinking approach should be applied to air quality.
RECOMMENDATION 4

Innovation

Innovation at Crossrail

1.36. The Chair invited the Innovation Programme Manager, Crossrail to give a presentation on Innovation:

- Focus on collaboration to innovate, Innovate 18 is their (semi-open) innovation programme.
- Team Structure and Governance:
  - Regular meeting the innovation team is having with the supply chain about best practise and innovation practise
  - Innovate 18 creates a network of people, champions between all the different projects. It is an open platform to share and encourage a culture of collaboration.
  - High innovation and high performance are correlated
  - Seed funding only. £400 to spend on proof of concept:
  - Use of IPads instead of paper
  - Using drones for construction
  - Overview of all invested projects
  - People feel empowered to share ideas.
  - People feel recognised. Non measurable impact (not on return on investment).
- Dissemination programme for best practice.
- Potential creation of an industry portal.
- Tried things that have failed and learnt from them
- Procurement side was streamlined.

TRL - Air Quality Grant recipient

1.37. The Chair then invited Kevin Turpin, Principal Consultant at TRL to give a brief presentation on the results of their project funded by a DfT Air Quality Grant.

1.38. The project was to upgrade and adapt existing equipment (FEAT) for remote sensing to measure real world emissions.

- The use of LEDs was a key part of the adaption process
- Field trials were conducted
- N02 was adequately identified
- The next step is to expand the trial
- The device could be fitted on vehicles and consideration as a hand held device to allow for greater flexibility in measurement sites.

Innovation at the DfT

1.39. The Chair then invited the Head of Science and Research Division to facilitate a discussion on 'Innovation at the DfT. The presentation contained the following prompts:

- Turning ideas into value
- MIT: Think big, start small, fail fast and scale quickly

- Catapult, Think big, take small steps and learn fast
- Fostering a culture of innovation within the DfT. Aim is to stimulate innovation and products
- Innovation Challenge Fund – There still is gap in that approach. What is the next step of deployment? It has to be challenge led. The money has to be spent within the financial year. The Department cannot host a Webinar because of IT limitations.
- Government set the Challenge on issues procurement cannot be established, even though it carries risks.
- The DfT will have to show value for investment
- 11 innovative projects were funded through the targeted air quality call. Summaries of the projects should be shared with SAC members. **ACTION 10**
- Deregulation process within the DfT to encourage businesses to further innovate £10bn has already been cut in 'red tape'. However, certain areas have regulations that are holding back the market, for example, autonomous vehicles and drones.

SAC response

- Procurement processes should be improved to capture innovation. **RECOMMENDATION 5**
- Developing the technology with seed funding is well supported, but scaling up the technology and getting into the market for SMEs is more challenging.
- 20% of Crossrail innovation are process related and not technology related.
- OLEV are considered to be innovative with their budget, request for a presentation on Innovation at a future SAC meeting. **ACTION 11**
- Do not exclude ideas that are not just technical in your procurement processes, human element is key. **RECOMMENDATION 6**
- Challenge led funding is to be encouraged, arrange challenge led stakeholder days.
- Environment for innovation at the DfT will bring value where people are encouraged to share ideas within the DfT and ideas outside the DfT are welcome. Consider an innovation portal where ideas can be shared.
- Timescale might be an issue to get this first call completed. Could a split year funding be considered e.g. 80% to cover the research one year and 20% for report writing the following year?
- Stimulate ideas that may lead to wealth creation, after that other mechanisms will support market uptake such as venture capitalists. The key is to demonstrate quick wins
- Potential ideas for the Innovation Challenge Project:
  - Crowd sourcing to get end users involved
  - Focus on specific areas of innovation or broad challenge, such as how TfL did, highlighting the challenges to be addressed
  - The first year could be used to further fund promising T-TRIG concepts.
  - Make challenges broad, don’t exclude ideas.

- Encourage the supply chain, consider demonstrators of first real use of operational systems.

Other Business

1.40. The Chair announced that this Council meeting would be the last for Clemence Cavoli as SAC Secretariat as her secondment into the Department had come to an end. The Chair thanked Clemence for her work and support to the SAC.

1.41. The Chair thanked the participants for their input during the day, confirmed that the next meeting would be on 20th July.

Annex E: Cyber and Data Meeting Minutes

Department for Transport

DfT Science Advisory Council
09:00 – 16:00 Wednesday 20th July 2016
Department for Transport, Room H1,
33 Horseferry Road, London SW1P 4DR

SAC Members
Professor Lord (Robert) Mair, Chair
Professor Ricardo Martinez-Botas
Professor Barry Clarke
Professor Eddie Wilson
Mr Paul Stein
Professor Paul Newman

Apologies
Professor Peter Jones

DfT Officials
Professor Phil Blythe, DfT Chief Scientific Advisor
Siobhan Campbell, Deputy Chief Scientific Advisor
Deirdre O'Reilly, Head of Social and Behavioural Research
Iarla Kilbane-Dawe, Head Partnerships and Engagement
Neil Ebenezer, Head Science and Research
Matt Coleman, Head of Data and Connectivity
Manny Chung, Senior Science & Technology Advisor

External Attendees
Roland Meister, Innovate UK
Paul Caseley, Defence Science & Technology Laboratory
Derwen Hinds, Government
Andrew Martin, University of Oxford
Christopher Hankin, Imperial College
Paul Galwas, Digital Catapult
Paul Zanelli, Transport Systems Catapult
Michele Hanson, Transport for London
Paul F, Government
Jeremy Morley, Ordnance Survey
Emyr Thomas, Highways England

Welcome, Introduction and updates

1.1. The Chair welcomed the Council Members, officials and guests and set out the agenda for the day. In particular, the Chair informed Members that Sue Duncan had tendered her resignation from the Council and thanked her for her contribution.

1.2. The Chair invited the Council secretariat to provide an update on the actions and recommendations from the last meeting. A summary of the actions is given in the table below.

Summary of Actions from last meeting:

No.	Action	Owner	Status/Outcome
1	Minutes of Council meetings to be published externally	Secretariat	Ongoing **ACTION 1**
2	Potential joint SAC meeting	Secretariat	Ongoing **ACTION 2**
3	Artificial Intelligence should be added to the list of future topics	Secretariat	This has been added to the list but needs to be defined as it is a broad subject area.
4	Systems Thinking slides to help inform further Systems Thinking activity in DfT	Secretariat	A workshop has been taken forward within the Department. **Council Members to review slides again. ACTION 3**
5	Disseminate and publish annual report including Condition Monitoring report and Customer Satisfaction	Secretariat	These reports will be published once a submission is cleared by Ministers.
6	Prof Lord Mair to facilitate contact with the Institution of Civil Engineers for dissemination	Prof Lord Mair	Lord Mair has agreed to take this forward.
7	Revised recommendations from the Customer Satisfaction report	Deirdre O'Reilly/Peter Jones/Sue Duncan	**Completed** and agreed by Council
8	SAC to write the foreword of the statement of needs.	Secretariat	This will be circulated to Members
9	Research commissioned by the DfT should be open to the public.	Secretariat	Research project reports will be published as a matter of course on the DfT website.

10	Draft research paper for second phase of the vehicle emissions review to be shared with the SAC.	Secretariat	**Completed**
11	Summary air quality grant projects of it to be shared with SAC Members.	Secretariat	**Completed**. This was provided to Members
12	OLEV to give a presentation on Innovation at a future SAC meeting	Secretariat	**A suitable time to be decided at a future SAC meeting. ACTION 4**

No.	Recommendation	Outcome
1	DfT should consider hosting 'Challenge Days' for policy teams to meet with academics	This is being taken forward with the first one being held in September.
2	DfT to prepare a suite of presentation slides to highlight the research needs of the Department	The statements of needs provide an overview of the Department's research areas.
3	Consider sponsoring Fellowship Schemes in collaboration with the Royal Academy of Engineering.	Discussions to be taken forward with RAEng.
4	Apply System Thinking to the air quality problem.	This will be taken forward in due course to help map out the problem.
5	Procurement processes should be improved to capture innovation.	The Department is considering how to capture innovation in procurement. The Council report on Condition Monitoring and Intelligent Infrastructure has been shared with the procurement team.

1.3. Members requested minutes of meetings to be available soon after meetings and emphasised the importance of publishing them externally. Members also asked to be kept informed of the outcome of actions and recommendations given by Members.

Update on Customer Satisfaction Measures across Transport

1.4. The recommendations of the customer satisfaction report were revised and consolidated following the discussion at the last Council meeting. An updated paper provided to Members was briefly discussed and agreed by the Council. The *ad hoc* Council group were thanked for their contribution.

1.5. The Social and Behavioural Research (SBR) team reported that it is exploring customer satisfaction with different modes via a single source i.e. the National Travel Survey. **It was agreed to update the Council once the pilot is complete. ACTION 5**. The SBR team has also brought together a question bank to help manage knowledge gathering, enable benchmarking and minimise duplication of effort on the attitudes and behaviours of people to transport in one useful source. The question bank is in the process of being disseminated.

Update on Innovation Challenge Fund and Targeted Calls

1.6. The Council was provided with an update on the innovation projects including the Transport Technology Research Innovation Grant (T-TRIG) and the Innovation Challenge Fund (ICF). The ICF will be to develop solutions to challenges faced by policy teams in the Department. The launch of both competitions was delayed due to 2 purdah periods. The T-TRIG would be launched on 23rd July and the ICF will launch in the Autumn.

1.7. The Department has previously undertaken two rounds of targeted competitions on air quality and looking to launch competitions in other areas. The Council was invited to provide their thoughts on topics for future targeted calls. **ACTION 6.**

Update on Horizon Scanning

1.8. The Council was informed that the Department's current horizon scanning contract was being terminated as it did not meet the needs of senior officials or policy leads. The Council was asked to suggest a replacement capability. Points to note included:

- The current service is extremely useful as it can bring technologies, challenges and opportunities to the attention of the Department;
- A broad scan of news and emerging issues presented in a structured way with minimal text, perhaps only bullet points, would be a valuable product. A densely populated document is not easy to read;
- The end-user and customer has to be better identified. Any future service should be tailored to what the policy customer needs;
- It would be helpful if documents were hosted on a platform that allowed a search function;
- Another horizon scanning capability should be implemented; there would be concerns if this function was to cease; **Point to consider 1.**

Data and Cyber Security

1.9. The main topic of discussion for the meeting was data and cyber security in the context of autonomous vehicles. The objective of the session was to better inform, advise and challenge the Department on the key issues regarding cyber security. In particular, the discussion was to inform the Department's cyber team on their approach to developing a programme of work on cyber security for autonomous vehicles. This session of the meeting opened with presentations to introduce the subject, inform discussion and set the scene.

Introduction: The Challenges of Data and Cyber Security

1.10. A wide ranging presentation was provided by a member of the Council on data and covered the volume of data generated, its value and issues surrounding ownership, accessibility and storage of big data. The presentation gave a perspective of how much data can be generated in a short amount of time, noting that more data has been generated in the past two years than in the entire human history. However, of all data generated, less than 0.5% is ever analysed and used. This raises the question of how data should be stored and who owns the data.

1.11. Key points to emerge were from the discussion were:

- The value of data is often not immediately obvious and so needs to be stored for future use. Therefore, storage is a potential barrier to exploiting the benefits of data;
- It is often difficult to determine ownership of data. This can pose challenges in the ability to use the data;
- The cost of memory and storage has fallen considerably over time. Key challenges remain as to:-
  - Who has access to data?
  - What will data reveal in time?
  - Who insures data?
  - Who secures data and how?
  - What role do governments have in an area that changes so quickly?

1.12. It was agreed to share the source article that informed some of the points presented in this discussion with those attending. **ACTION** 7**.**

Cyber Security - Defence and Transport

1.13. A presentation on the safety and security of data and cyber, comparing defence and transport, was provided by an external attendee. The presentation and discussion touched on data solutions and architectures of systems. It was noted that modern cars are increasingly connected and controlled by software. Effective means to make them safe and secure requires more effort. A collaborative approach between the automotive industry and security researchers can help discover and address flaws before adversaries and accidents can impact vehicle safety.

1.14. Systems need to be secure and safe by design. Good standards can help support this as well as built in monitoring systems.

1.15. Key points to emerge from the discussion were:

- Cyber is seen as a credible source of hazard;
- Data is also considered a source of hazard;
- Automatic functions in systems should be mathematically deterministic with security and safety features;
- Autonomous functions may be constrained by automatic functions;
- Automatic security updates are needed to patch vulnerabilities;
- Public trust is a key issue to the benefits realisation of data;
- There is a skills shortage which requires serious consideration by government;
- Particular attention is needed where there is a crossover of autonomy and cyber.

Cyber Security in Connected and Autonomous Vehicles

1.16. A presentation on cyber security in connected and autonomous vehicles, looking at lessons learned from existing systems and emerging technology featured in the meeting. The presentation noted that all systems have vulnerabilities and there is a broad range of cyber threats that have evolved over time, from internet worms to targeting connected devices with the value and number of threats increasing. However, the great majority of successful attacks are routine and very few adversaries have the motive and resources to carry out sophisticated attacks.

1.17. Points of discussions included:

- There are safety malware threat classes, including collateral damage, deliberate sabotage and 'modding' (the modifying of hardware or software) that need to be addressed at different levels;
- Economic threat classes include extortion by threatening sabotage and threats of vehicles and contents;
- A comparison of the security between PCs, smartphones, smart TVs and vehicles demonstrating the secure design of smartphones exceeding that of PCs;
- Systems are updated regularly, however, it can still be fragmented and although software is increasingly more complex, this also leads to increased vulnerabilities;
- Innovation in security is always required as today's designs will not be fit for purpose tomorrow;
- Smartphones are leading the way in security design. Differentiating factors include:-
  - (broadly) open designs;
  - Detailed security models;
  - Better operating system sandboxing;
  - Effective removal of admin rights from user;
  - Software launch/deployment control;
  - Isolated secure storage.

  Although it was noted that 'rooting'/jailbreaking is carried out.
- Architectural faults cannot be easily fixed at a later time. It is better to have an up-front design which is robust and open to review;
- Modification of vehicle software by owners or third parties is a complex area and poses potential vulnerabilities and actions to mitigate these are needed.

Cyber Security across Government

1.18. The Deputy Director of National Security at the Department provided an overview of cyber security across government and an insight into the areas of work for the Department. The presentation covered:

- The threats and vulnerabilities faced by an ever increasing world of connectivity;
- The government's cyber security strategy which has involved a national cyber security strategy in 2011 was refreshed in 2015 with an increase in investment. It also established a National Cyber Security Centre to help coordinate cyber effort and provide a single point of contact for advice to the public and private sector;

- The establishment of a new Department cyber security team whose purpose is to provide expertise and resource to set expectations and assure mainstream cyber security by industry. The team focuses on aviation, rail, maritime and connected and autonomous vehicles.

DfT's Approach to Cyber Security in Connected & Autonomous Vehicles

1.19. The main item for discussion was led by the cyber security and connected and autonomous vehicles (CAV) teams. A paper was presented to the Council outlining the challenges facing the teams in developing a connected and autonomous vehicle cyber strategy and a programme of work they currently have underway.

1.20. It was first outlined that privacy, standards and regulation with regards to data is an area the Department is focusing on and further thought on this is needed. Connected and autonomous vehicles are clearly a source of data and cyber vulnerability, however, vulnerabilities do also exist in other devices and lessons should be learned from other sectors such as finance. The Department is keen to see the benefits of CAV technology, and the risk presented from cyber should not be a barrier to innovation.

1.21. Key points of discussion amongst attendees included:

- A distinction needs to be made between autonomous and connected vehicles as there can be vehicles that are autonomous but not connected;
- It is important to ensure regulation does not become a barrier when setting standards. Furthermore, vulnerabilities will change over time and will need to be monitored regularly;
- The connectivity of a vehicle is the aspect that makes them hackable;
- Real-world testing would be helpful in answering the 'what if' question.

1.22. Drawing on the presentations and discussions through the day, it was noted that there is a need to consider today's vulnerabilities of a connected world but not lose sight of the emerging and ever increasing system of autonomy. It was mentioned that autonomous but not connected vehicles should be considered and that there is a need to build "security mindfulness" into the design, supply chain, and procurement. Skills shortages at the primary school level were noted, as well as capable data analysts being needed for the UK to remain a leader in this field.

1.23. The cyber and connected and autonomous vehicles teams presented the Council with their approach to developing a strategy for cyber security and asked specific questions of the Council as detailed below.

Questions to consider

- What could the role of Government be to ensure the cyber security of the CAV ecosystem?
  - What are the options open to government?
  - Which might be most effective?
  - How can we ensure that these actions do not stifle innovation and can be responsive to change?
- What lessons can we learn from other fields?

  - Energy, Critical National Infrastructure (CNI), finance, telecoms, vehicle safety and other industries have all been on similar journeys of how to cope with new paradigms. What approaches and lessons from these industries, such as the use of standards, could be appropriate for cyber security and CAV?
- What approaches could be used to ensure cyber security is embedded within the automotive supply chain?
  - What are the options open to car manufacturers or government?
  - Which might be most effective?
- Where might there be industrial opportunities for the UK
  - What capabilities does the UK have that could be applied to this area?

1.24. In response to the questions asked, and wider discussions held during the course of the meeting, the following key points were made:

- There may be lessons to learn from other sectors such as aviation whose level of risk can be thought of as greater due to the higher occupancy of an aircraft compared with a road vehicle and greater consequences of an accident;
- Dual purpose opportunities where environmental/safety issues could be addressed simultaneously with security;
- The opportunities to dovetail CAV work with that of BIS's Digital Built Britain Security Working Group to ensure that managed information-sharing is adequately considered;
- Work by other government departments to rapidly address Building Information Modelling (BIM) security issues without cramping the innovation/collaboration that BIM developments can bring and the synergies between that and CAV current challenges;
- Are changes in the infrastructure and systems architecture needed? e.g. should emergency service vehicles be given priority?
- The importance of having a forensic footprint for accident investigations is important. Perhaps consideration should be given to reporting near misses as well as accidents;
- Consideration should be given to developing a matrix to distinguish between autonomous and connected vehicles, with a timescale dimension (short-term versus longer term; **Point to consider 2.**
- The whole ecosystem of cyber security involves physical and personnel initiatives to mitigate issues and vulnerabilities; **Point to consider 3.**
- The need to consider work by others on protecting specialist vehicle fleets and how that could assist; **Point to consider 4.**
- Skills shortages should be addressed early on. As increasing autonomy develops in the 3 - 30 year time horizon the UK needs to develop a talent pipeline, starting with primary-aged school children. The Department should consider working with the Department for Education in developing the skills needed for the future generation; **Point to consider 5.**

- Government should use its convening power to bring together the key people, e.g. British Standards Institution (BSI); **Point to consider 6.**
- Government should consider how and what role it can play in promoting manufacturers to learn from each other; **Point to consider 7.**
- Government should take a risk-based approach and consult professional institutions and the public to determine risk. **Point to consider 8.** This has the potential to assess risk early on whilst embracing innovation. What is the level of residual risk we are prepared to accept as a society? There maybe market failure (information asymmetries) whereby the consumer does not know level of residual risks in order to make an informed purchase. Moreover, commercial residual risk may not be the same as that of the customer. How can we ensure that the risks are properly socialised within government, the professions and wider society? **Point to consider 9.**
- Risks associated with theft of vehicle (or its contents/cargo) should be considered in addition to sabotage; **Point to consider 10.**

Any other business

1.25. The Chair confirmed 26th October 2016 as the date for the next Council meeting.

Actions Log

No.	Action	Owner
1	Minutes of Council meetings to be published externally	Secretariat
2	Potential joint SAC meeting	Secretariat
3	Council Members to review draft Systems Thinking slides	Council Members
4	OLEV to give a presentation on Innovation at a future SAC meeting	Secretariat
5	The Social and Behavioural Research team is piloting an end-to-end journey survey for the National Travel Survey. A presentation of this work will be given to the Council at a future meeting.	Deirdre O'Reilly
6	Council Members to suggest topics for targeted call competitions	Council Members
7	It was agreed to share the source article that informed some of the points presented in the challenges of data and cyber security discussion	Paul Newman

No.	Points for consideration
1	Continue with Horizon scanning in some capacity

2	Consideration should be given to developing a matrix to distinguish between autonomous and connected vehicles, with a timescale dimension (short-term versus longer term).
3	The whole ecosystem of cyber security should be considered. This involves physical and personnel too.
4	The need to consider work by others on protecting specialist vehicle fleets and how that could assist
5	The Department should consider working with the Department for Education in developing the skills needed for the future generation.
6	Government should use its convening power to bring together the key people, e.g. British Standards Institution (BSI)
7	Government should consider how and what role it can play in promoting manufacturers to learn from each other.
8	Government should take a risk-based approach and consult professional intuitions and the public to determine risk. This has the potential to assess risk early on whilst embracing innovation.
9	Ensure that the risks are properly socialised within government, the professions and wider society.
10	Risks associated with theft of vehicle (or its contents/cargo) should be considered in addition to sabotage

Annex F: Hyperloop Meeting Minutes

Department for Transport

DfT Science Advisory Council
10:00 – 16:00 Wednesday 26th October 2016
Department for Transport,
Room H4 & H5, 33 Horseferry Road, London SW1P 4DR

SAC Members
Professor Lord Mair, Chair
Professor Peter Jones
Mr Paul Stein
Professor Ricardo Martinez-Botas
Professor Barry Clarke
Professor Paul Newman
Professor Eddie Wilson

Internal Attendees
Professor Phil Blythe, Chief Scientific Adviser
Neil Ebenezer, Head of Science and Research Division
Iarla Kilbane-Dawe, Head of External Engagements and Partnerships
Matt Coleman, Head of Data and Connectivity
Manny Chung, Secretariat
Mark Gaynor, Head of Technical Strategy
Selorm Davoh, Assistant Economist
John Baverstock, Senior Researcher
Iain Roche, Iain Roche, HS2
Peter Lee, Head of Future Roads Technology Strategy
Sevvy Palmer, Economic Advisor

External Attendees
Tessa Darley, Knowledge Transfer Network
Kelvin Davies, Innovate UK
Roland Meister, Innovate UK
Keith Hodgkinson, Department for Business, Energy & Industrial Strategy
Professor John Loughhead, Department for Business, Energy & Industrial Strategy
Alan James, Hyperloop One
Kaveh Hosseini, Hyperloop One
Phill Cartwright, High Value Manufacturing Catapult
Paul Gallen, National Composite Centre
Dan Kells, National Composite Centre
Professor Nick Reed, TRL
Rebecca Jones, Foresight, GO-Science

Professor John Miles, University of Cambridge
Professor Richard McMahon, University of Warwick
Professor Roger Goodall, University of Loughborough
John McCarthy, Atkins

Welcome, Introduction and updates

1.1. The Chair welcomed Council members and set out the agenda for the day. The Chair invited the Council secretariat to provide an update on the actions from the last meeting. The minutes and actions from the previous meeting on 20 July 2016 were agreed without amendments. A summary of the outcome of the actions from the last meeting is given in the table below.

No.	Action	Owner	Status/Outcome
1	Minutes of Council meetings to be published externally	Secretariat	Minutes or a summary of minutes to be added as annex to annual report as minutes cannot be published on .gov.uk. **ACTION**
2	Potential joint SAC meeting	Secretariat	A common purpose has still to be identified.
3	Council Members to review draft Systems Thinking slides	Council Members	**Completed.**
4	OLEV to give a presentation on Innovation at a future SAC meeting	Secretariat	**OLEV has agreed to this.** **ACTION OPEN**
5	The Social and Behavioural Research team is piloting an end-to-end journey survey for the National Travel Survey. A presentation of this work will be given to the Council at a future meeting.	Social Behavioural Research Team, DfT	**ACTION OPEN**
6	Council Members to suggest topics for targeted call competitions	Council Members	**Completed**
7	It was agreed to share the source article that informed some of the points presented in the challenges of data and cyber security discussion	Paul Newman	**Completed**

1.2 Points 2 – 10, in the table below, for consideration from the meeting in July were addressed by the update provided by the Centre for Connected and Autonomous Vehicles. **Point 1** will be taken forward in the form of a project by the Government Office for Science looking at the Future of Mobility.

No.	Points for consideration
1	Continue with Horizon scanning in some capacity

2	Consideration should be given to developing a matrix to distinguish between autonomous and connected vehicles, with a timescale dimension (short-term versus longer term).
3	The whole ecosystem of cyber security should be considered. This involves physical and personnel too.
4	The need to consider work by others on protecting specialist vehicle fleets and how that could assist
5	The Department should consider working with the Department for Education in developing the skills needed for the future generation.
6	Government should use its convening power to bring together the key people, e.g. British Standards Institution (BSI)
7	Government should consider how and what role it can play in promoting manufacturers to learn from each other.
8	Government should take a risk-based approach and consult professional intuitions and the public to determine risk. This has the potential to assess risk early on whilst embracing innovation.
9	Ensure that the risks are properly socialised within government, the professions and wider society.
10	Risks associated with theft of vehicle (or its contents/cargo) should be considered in addition to sabotage

2. Update on Condition Monitoring & Intelligent Infrastructure Report

2.1. The Council was provided with an update on the progress of dissemination of the condition monitoring and intelligent infrastructure report. The report was presented to the Heads of Procurement at DfT, including Network Rail and Highways England. Procurement professionals were keen to take forward the recommendations made in the report, and steps to allow them to do that exist. Heads of Procurement were also keen to learn of further case studies to demonstrate the impact of intelligent infrastructure.

2.2. The aspirational next steps for this report are to work with teams in the Department to deliver the recommendations through a programme of work. It is envisaged that the customer base for this could involve the Road Investment Strategy and HS2.

2.3. Council members made the following comments:-

- Procurement can be done in two ways; retrofitting or procurement of new things. Retrofitting in transport is a good option to consider as this can deliver quick wins and is often faster than implementing new infrastructure;
- Condition monitoring of landslides will be a good exemplar of smart sensors as will bridges owned by Network Rail and Highways England. Particularly as many bridges are dated Victorian masonry bridges and susceptible to scour;
- Degradation of roads is also a good application;
- Procurement should be considered earlier in the process as often things discussed at the design stage are lost when it comes to procurement.

2.4. The Chair informed the Council of a meeting with the Department's Permanent Secretary, Non-Executive Directors and the Chairs of DfT's stakeholders – Network Rail, Highways England, Transport for London and HS2 to discuss condition monitoring. The focus of the meeting was on procurement and the Permanent Secretary was keen to discuss the issue at a higher level.

2.5. The Chair also notified the Council of a meeting to be held on 4th November at the Institution of Civil Engineers with procurement experts where condition monitoring will be discussed.

2.6. A Member provided an example of a maritime retrofit, the work that was done, the benefits realised and the need to develop a convincing business case. The Council agreed that there was a strong need for good business cases to be developed for different sectors.

3. Update on DfT's Cyber Security Strategy for Autonomous Vehicles

3.1. The Council was given an update to the recommendations made at the last meeting on the Department's cyber security strategy for autonomous vehicles.

3.2. The update included:-

- The Centre for Connected and Autonomous Vehicles (CCAV) has engaged closely with industry to raise the profile of cyber and security to set standards;
- Industry is being encouraged to develop a maturity assessment to demonstrate how well it is prepared to meeting the principles set out by government;
- Work with the USA counterparts on cyber security has shown that principles are well aligned with the UK and an international approach to setting standards would be beneficial;
- An information exchange launch in January 2017 on connected and autonomous vehicles will allow CCAV to develop its thinking on risks.

3.3. The Council commented that it is important to consider both connected and autonomous systems, and that due to the range of factors involved in cyber protection, an international approach would be of benefit. The Council also noted that a clear distinction should be made to the type of road vehicle being discussed.

4. Road Technology Scenarios

4.1. The Department has recently commissioned Atkins to develop a set of technology-focused transport scenarios 2025-2040. The project will help DfT ensure strategic planning, analysis and decision-making around medium-to-long-term transport policy and investment to take account of the potential impacts of future technological change and uncertainty.

4.2. The Council was presented by Atkins with a high level overview of the approach to the work. Comments and discussions points to emerge were:-

- The pace of change of technology is fast and there is a lot of convergence of technologies;
- A systems of systems approach can help break down the silo workings between different expertise;
- The uncertainties need to be identified before considering what the future may look like;
- Societal implications of technology need to be addressed;
- User experience should focus on society as a whole, not individuals;
- Connected systems and technology should consider rural communities;
- Technology innovation paths should take account of component parts.
- Technology road maps should help focus research. Batteries was given as an example of how their development will change as technology develops over time;
- City and town planners should be consulted as housing can often play an important role for future national infrastructure builds;
- Previous future predictions should be consulted to learn from failures;
- Shift in modes of transport in future should be considered;
- Energy implications of technology should be considered.
- Future of travel demand

4.3. Atkins offered to engage with SAC members to improve the outputs of the project. **ACTION**

5. Hyperloop – Opportunities for the UK

5.1. The main topic of discussion was Hyperloop and the opportunities this could offer the UK. The objective of the session was to help inform the UK government's position on this technology.

5.2. Preliminary work on exploring the system for the UK has been carried out by Innovate UK, DfT, and Department for Business Energy and Industrial Strategy (BEIS).

5.3. The discussions were centered on how UK plc can benefit from Hyperloop, taking account of the challenges the technology presents and how it may fit into the wider UK transport system. The Council was asked to focus on the technology and engineering aspects of the system to consider whether it is a feasible concept for the UK. The session of the meeting opened with presentations to introduce the topic and inform the discussion.

Hyperloop One

5.4. A presentation of a Hyperloop system was given by Hyperloop One. This is one of a number of companies that are looking at the potential development of this technology as recently described by Elon Musk in a White Paper that formed the basis of the discussion on this topic.

5.5. The main points to emerge from the presentation and following discussion included:-

- The Hyperloop system involves a pod which can be sized to carry freight or passengers. The pods operate in tubes which creates a controlled environment where the air pressure is reduced considerably to eliminate almost all resistance. The pod is propelled by a linear electric motor. To eliminate friction, pods are levitated. It uses passive Maglev technology (position of magnets causes the levitation);
- A fully operational prototype is expected in the first quarter of 2017;
- There is a proposal to create an underwater Hyperloop system from Stockholm to Helsinki to connect the Finnish and Swedish economy. There is a view to connect to the main transport network through smart interchanges and point to point journey stops;
- The UK is seen as a potential testbed for a proof of operations facility due to the highly skilled workforce and high technology manufacturing base;
- The key areas of engineering innovation of the system were: the tube structures, pods, motors, levitation, control systems and power electronics;
- Detailed analysis is currently underway to compare the energy consumption of Hyperloop with other transport modes;
- An appropriate regulatory framework will need to be developed for this system.

Hyperloop Challenges

5.6. A presentation by a Professor of Transitional Energy at University of Cambridge was given. The presentation and discussion focused on the engineering challenges and aspects of the system. The key points from the presentation and discussion included:-

- For the UK, Hyperloop has the potential to be part of a national underground system that connects the north to the south through a tunnel system, and could connect the 3 main airports in the South East;
- This boost in infrastructure can significantly increase capacity to stay ahead of the demand curve;

- The benefit of having the system underground allows considerably easier negotiation of suburban and heritage areas. However, this would increase infrastructure cost;
- Reduced pressure concepts in transport have so far not been practical;
- The pod would use Maglev suspension via permanent magnet (passive) 'repulsion' system with horizontal 'maglev' for lateral guidance;
- A linear motor propulsion would be used for acceleration and deceleration;
- Retractable wheels would allow for low-speed manoeuvring
- The pods can look like and be the size of small regional aircrafts;
- Speed of travel will be similar to speed of travel in air;
- Operational security of the tunnels can be achieved through isolating sections where there are any failures. Pods can have air masks in case of emergencies;
- Tunnels in the UK are currently designed to be water-tight, however they are not designed to be air-tight. This means that air needs to be pumped out of the Hyperloop tunnel constantly to maintain the low pressure. Air ingress checks will need to be made;
- Construction tolerances need to be considered during the design and construction of the tunnels;
- Geological challenges in tunneling may increase the overall cost of the tunneling;
- Looking at the cost to value estimate of Hyperloop, it is around £40-£100m/mile. Heavy rail currently is around £200m/mile;

Discussion Questions

5.7. A paper was provided by the DfT policy lead in advance, requesting the Council's advice on specific questions to help the Department take forward its work in this area. The questions and responses were:-

a) Does the overall Hyperloop concept appear credible from a technical perspective?

- From a technology perspective it is credible;
- There is research being carried out on magnetics in tube systems; and it is technically feasible;
- Hyperloop is looking to connect various different systems together. State of the art software and hardware technologies can create a more accurate model of what the system will look like (computer simulations are now more mature);
- Simulations and modelling approaches have their limitations and do not go far enough to test the physics of the system
- The challenges of increasing the size of the system from a test site to a practical city application are unknown – and will remain unknown until it is constructed and modelled.

b) What do you see as the main technical challenges around the propulsion and control systems and the physical construction?

- Cooling the system is a big challenge – track heat needs to be dispersed;
- Drag ratio, electrical discharge and insulation are all challenges that need to be considered;
- Switching from multiple tubes and serving different stop destinations;
- Gravitational optimisation (G-force) and pod rotation all need to be considered as part of the passenger comfort in the stop/start section of the journey;
- Stabilisation -stable running –damping;
- Switching at high speeds in a pod based system that has a tilt based system;
- Further thoughts on human factors consideration are given in Annex A.

c) What opportunities could Hyperloop offer to UK industry given our technology and engineering expertise?

- The UK aerospace supply chain has technology that can be used and skills to develop some of system;
- The UK has capability in composite material technology that can be utilised in developing this system;
- The UK has some of the most successful vacuum system design companies as well as high level of skills in power-electronics;
- The UK also has huge tunnel building knowledge and is becoming a leader in 3D printing;
- The UK is already a forerunner in safety regulation; there is now potential to develop the regulation and standards of Hyperloop.

d) Assuming Hyperloop becomes a viable transport system, how would it fit with existing transport infrastructure and what implications might it have for wider infrastructure development e.g.: housing, education, health?

- Consideration has to be given as to whether it will be socially acceptable and if people will use it;
- If it is built underground it needs to connect to existing infrastructure through key integration points;
- The most impact will be due to the huge increase in connectivity (commuting distances will change);
- There may be risks of existing inter-city rail networks suffering and need to be subsidised as a result. Alternatively the development of Hyperloop could free-up smaller location capacity.
- The SAC were challenged to consider the lost opportunity cost of not supporting a technology that has the potential to be disruptive to future transport plans.

6. AOB

6.1. The Chair thanked all the Council members and attendees for their contribution to the meeting.
6.2. Dates for future Council meetings to be set up. **ACTION**

7. Action Log

No.	Action	Owner
1	Minutes of Council meetings to be published externally	Secretariat
2	OLEV to give a presentation on Innovation at a future SAC meeting	Secretariat
3	The Social and Behavioural Research team is piloting an end-to-end journey survey for the National Travel Survey. A presentation of this work will be given to the Council at a future meeting.	Social Behavioural Research Team, DfT
4	Atkins to engage with Council members on the futures scenarios work	Peter Lee/Atkins
5	Dates for future SAC meetings to be agreed	SAC Secretariat

Annex G: Position Statement on Hyperloop

Overview

1. The Department for Transport's Science Advisory Council (SAC) met on 26 October 2016 to discuss Hyperloop technology.

2. The SAC considered the technical feasibility of Hyperloop and how this technology could be utilised in Britain's future transport infrastructure. The Council also considered how the UK's science, engineering and advanced manufacturing capabilities could support the development and delivery of Hyperloop technology.

Background

3. Hyperloop was first proposed in a 2013 paper by the American entrepreneur Elon Musk, which outlined a tube-based system where pods transported passengers or freight at very high speeds in a low friction environment.

4. A number of organisations are currently working to develop and commercialise this technology. The technical aspects of each proposal vary; however the key elements of each system include:

    i. A tube containing a low pressure, controlled environment;
    ii. Sealed pods carrying freight or passengers; and
    iii. A system for levitating and accelerating pods inside the tube.

5. The anticipated end result is a high speed transport system that, compared to conventional planes, trains or cars, is also very energy efficient because of the lack of air resistance and rolling resistance.

6. One of the organisations working to commercialise this technology, Hyperloop One, delivered a presentation to the SAC. However, this paper does not evaluate the proposals of any specific Hyperloop developer, but rather assesses the concept as a whole.

7. During the meeting, the SAC considered:

    i. The technical feasibility of Hyperloop technology;
    ii. The benefits and challenges of building Hyperloop infrastructure in the UK; and
    iii. The opportunities for the UK engineering sector and supply chain to support the development and delivery of Hyperloop technology.

Technical feasibility

8. The SAC recognises that the fundamental elements of Hyperloop are based on established technology including: maglev propulsion, linear induction motors, vacuum pumps and autonomous vehicle control systems. The SAC considers that enabling these elements to work together in a controlled manner at very high speed is the core technical challenge around the successful development and implementation of Hyperloop systems.

9. The SAC recognises that, whilst there are some specific design and operational challenges to be overcome there is nothing in the fundamental Hyperloop concept that would prevent it from being able to operate safely and securely.

Technical challenges

10. Hyperloop systems are intended to operate at very high speeds, with short headways - potentially with headways of as little as 10 seconds between pods – in a sealed, low pressure environment. This challenging environment introduces a range of risks that will require careful consideration in the design and operation of Hyperloop systems. Examples include, emergency braking at very high speeds, power failure, protection from physical and cyber attack and the protection and evacuation of passengers in case of a depressurised tube or pod.

11. The topology of the UK, its dense population and intensive land use may make Hyperloop construction more difficult and costly than in other locations. As an example, it may prove challenging to find a suitable alignment above ground for a Hyperloop system to enable it to operate at high speeds (requiring shallow gradients and curvature to limit "g" forces on passengers) without impacting on existing infrastructure or protected areas. This may necessitate full or partial underground construction, which would have a significant impact on capital costs and would make maintenance and emergency evacuation more difficult. There may also be significant challenges in tunnelling in parts of the UK depending on the local geological conditions.

12. Although not a technical issue, the SAC recognises that the radical nature of Hyperloop may raise some issues around passenger acceptance. This is not unique to Hyperloop as similar debates happened following the development of rail systems in the 19th century and aeroplanes in the 20th. But it will be critical for the success of the systems to demonstrate to passengers that Hyperloop systems will operate with the highest levels of safety and reliability. Similarly it will be important to ensure that passengers do not feel unduly confined within passenger pods and do not experience excessive or uncomfortable g-forces.

13. The SAC notes that, because of its unique design and operational characteristics, Hyperloop systems may require a new regulatory framework and associated safety standards.

Potential benefits of Hyperloop for the UK

14. The SAC recognises that a UK Hyperloop network has the potential to stimulate economic development across the country by substantially reducing journey times. Indeed, stated maximum speeds of around 700 mph corresponds to travel times of less an hour between most UK destinations. This could have a transformational impact, for example allowing commuters to live anywhere within the country and easily commute great distances. It would also provide a means of connecting separate towns and cities to deliver agglomeration benefits.

UK capability for developing and delivering Hyperloop systems

15. The SAC believes that the United Kingdom has a significant level of relevant expertise and experience from its strong academic and industry base to support the worldwide development and delivery of Hyperloop systems. This includes expertise in the following areas:

- autonomous vehicles;
- aerodynamics;
- control systems;
- energy management systems;
- advanced materials;
- tunnelling;
- design and delivery of major civil engineering projects;

- whole-life asset management; and,
- project finance and professional services including legal, financial, architectural and engineering

Conclusions

16. The SAC recognises the potentially transformative impact that Hyperloop systems could have on passenger and freight transport in UK and around the world.

17. The SAC notes that the fundamental elements of Hyperloop are based on established technologies but that there remain significant engineering challenges in enabling these elements to work together in a safe and effective system.

18. Proof of concept demonstrations are planned over the next twelve months by a number of Hyperloop developers. If successful, these will help to demonstrate that the concept is feasible from a whole-system perspective.

19. After initial demonstrations have shown that the core elements of Hyperloop technology have been successfully integrated, the SAC believes that British engineering expertise supported by our strong professional services and infrastructure delivery sectors could play an important role in developing and commercialising the technology.

20. The SAC will continue to review the progress of Hyperloop and may make specific proposals to the Department. In the meantime we recommend that the Department:-

    - continues to monitor closely the development of Hyperloop technology;

    - assesses in more detail the capability of the UK to support the design, development and delivery of Hyperloop technologies; and

    - works in partnership with BEIS, Innovate UK and regional bodies to explore the potential applications of Hyperloop as a transport mode within the UK.