Areas of Research Interest 2021

Research and Evidence

Contents

Foreword by DfT's Chief Analyst and Chief Scientific Adviser

DfT has a strong record of producing and using high quality research and evidence to underpin the development of our policies and operations. In recent years, research generated evidence has supported DfT's key infrastructure and transport system improvements such as High Speed Rail (HS2), new road schemes, and Crossrail. We also depend on high quality research and evidence when responding to challenges and risks, with science, analysis and modelling being central in driving the DfT's response to Covid-19.

As we build back better from the pandemic, delivering on our wider commitments for transport is now even more important. Just as having good evidence has played a vital part in DfT's recent successes and challenges, the continued development of our evidence base is necessary to ensure that DfT can deliver its strategic priorities effectively and respond well to future challenges.

DfT has an ambitious programme focused on five strategic priorities: to improve connectivity across the United Kingdom and grow the economy by enhancing the transport network; to improve users' experience by ensuring the network is safe, reliable and inclusive; to take urgent action to tackle climate change and improve the air quality by decarbonising transport; to increase our global impact; and to be an excellent department. Science and analysis are essential to achieving these priorities, and they need to be at the heart of DfT's decision-making to enable us to deliver our programme of work effectively and meet the challenges along the way.

To support this, we are publishing this updated Areas of Research Interest (ARI) for 2021, alongside the new DfT Science Plan. The Science Plan sets out our vision for science and lays out firm foundations for how DfT will provide leadership and coordination across the transport R&D community so we can both realise the unique opportunities science brings and address the challenges we face together.

The ARI sets out our strategic evidence and research needs for the medium-long term to help achieve DfT's wide-ranging and ambitious objectives. It is vital that DfT and the wider transport research community work together to help meet these ambitions along with the challenges and opportunities ahead. Therefore, we have refocused the ARI to show how

our research and evidence needs directly support the delivery of the DfT Strategic Priorities.

This document is a vital instrument for DfT to communicate our priority evidence and research needs. It builds on the work led by the previous DfT Chief Scientific Adviser, Professor Phil Blythe, who recently departed the role, and to whom we express our deep gratitude to for building the foundations of this ARI. We invite the UK's research community to actively engage with us and align your research programmes with the priority areas outlined in this document.
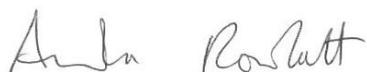
Amanda Rowlatt   Professor Sarah Sharples

DfT Chief Analyst   DfT Chief Scientific Adviser

1. Introduction

Purpose

1.1 This document builds upon the Department's 2019 Areas of Research Interest (ARI) and provides an updated account of research and evidence needs. The document is not intended to be a list of projects or invitations for contracts, but a list of research themes and priorities for DfT.

1.2 The purpose of this document is to communicate a summary of DfT's medium to long term research and evidence needs with researchers outside the Department, providing transparency and clarity and inviting collaboration. This will enable:

- the alignment of external research with DfT's priorities, maximising the opportunity for research impact and encouraging research capacity to grow in our areas of interest;
- an increase in the number and diversity of the delivery partners DfT work with, including by drawing on a wide range of UK and international expertise and evidence;
- the facilitation of partnerships with other funders and research programmes, enabling research to be delivered more collaboratively and efficiently, and identifying ways we can better work together towards shared goals; and
- the development of a more robust evidence base, strengthening DfT's ability to make well-informed decisions, ensuring public money is spent efficiently, policies are well-targeted, uncertainty is reduced, and anticipated benefits are achieved.

Scope

1.3 The ARI targets where DfT has identified there is most scope for further research to increase and deepen our understanding of these issues and where they believe the external research community is well placed to enhance the evidence base. These research priorities cover the full breadth of the department's policy areas which are detailed below:

- Aviation
- Environment and Future Mobility
- Maritime
- Transport Security, Resilience and Response
- Local Transport

- Regions, Cities and Devolution
- Road Safety, Standards and Services
- Strategic Roads, Economics and Statistics
- Analysis and Science
- Strategy and Private Office
- Rail
- High Speed Rail
- Communications

1.4   As DfT's research and evidence requirements are extensive and evolve, the ARI is not an exhaustive list of our needs but is intended to open conversations. We are also interested in research that is outside the areas outlined below, which may still be relevant to DfT policy or delivery. The purpose of this ARI is not to constrain the research done but to provide guidance about the topics where further research is most likely to have a positive impact on policy. Our specific evidence requirements may also adapt to reflect live departmental priorities, for example helping to inform the evidence base underpinning the government and department decisions on the UK's exit from the EU and the Covid-19 pandemic.

DfT's Science Plan

1.5   In parallel to the ARI, we have published DfT's Science Plan which sets the vision for research, development, natural sciences, social and behavioural sciences, engineering and innovation in the Department. It shows the role DfT is playing in the Government's ambitious vision for science and outlines how DfT will provide leadership and coordination across the transport R&D landscape to achieve our Strategic Priorities.

1.6   The Science Plan and the DfT Areas of Research Interest are companion documents, designed to work together to address DfT's Strategic Priorities. Together, they tackle the "what" and the "how" to ensure DfT and the transport sector plays their roles in making the UK a science superpower. The scope of the ARI is broader however, encompassing all of the analytical disciplines.

How DfT uses Evidence

1.7   Research and evidence are critical to forming robust policy and the Department has a strong history in the use of analysis to support policy making. We are growing our ambition in the use of science evidence for policy making and recognising the role, science, technology and engineering play in delivering policy more effectively and efficiently, as detailed in the Science Plan.

1.8   All policy decisions make use of a range of evidence sources to support the options generated and the recommendations provided. This evidence ranges from internal data analysis, modelling, social and behavioural science, economics, science and engineering and research and development (R&D) expertise through to externally commissioned research which taps into market leading expertise. This evidence is then provided to Ministers to support the policy decision making process along with legal, financial, ethical and other considerations.

1.9 DfT's research and analysis needs are met in a variety of ways to ensure the most timely, focused and cost-effective evidence generation. This ranges from the research that DfT directly commission (the top of the pyramid) to working with and influencing others to fund or conduct relevant research. The department also exploits existing research to influence policy.
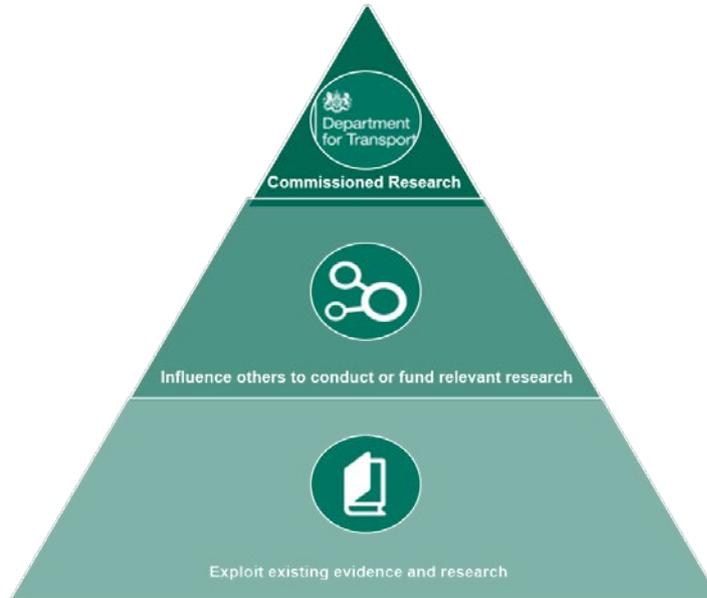
1.10 DfT uses a broad range of different research types to meet our evidence and policy needs, including:

- reviewing and synthesising existing evidence, research and expert knowledge;
- conducting secondary analysis of existing data sources;
- commissioning new evidence generation, both qualitative and quantitative (through a variety of procurement options and competition exercises);
- developing analytical tools for modelling and forecasting;
- evaluating policies and investment programmes;
- monitoring and surveillance;
- data analytics and data visualisation;
- research and development projects to prove concepts and test ideas;
- undertaking trials, pilots, living labs and demonstrators; and
- influencing and providing a steer to the research programmes of others to help align them with the Department's needs.

1.11 DfT covers an extensive range of policy areas as detailed in section 1.6 so the evidence we use is varied and requires a breadth of methodologies. This is demonstrated by the number and diversity of questions provided in the ARI.

1.12 We are keen to hear from the full diversity of disciplines and beyond traditional transport research and analysis providers. Innovation in methodologies, processes and techniques often comes from adjacent and even completely unrelated fields to transport and we are keen to reach experts in these areas and bring their work to bear on our challenges. We are particularly keen to hear from multi-discipline groups as we appreciate the importance of cross-discipline working and the increasing

interconnectedness of evidence needs, for example, increasing the behavioural and social science elements of all the evidence we collect or generate.

Dissemination and Engagement

1.13 Publication of the ARI is the first step of our engagement with stakeholders outside of government. Our engagement will include:

- A series of virtual engagement events across the UK with academic institutions and wider industry, innovation and transport sectors (with support from senior scientist and analyst communities in DfT). This includes both academic knowledge brokers and the academics themselves. We will work with organisations such as the Universities Policy Engagement Network (UPEN), Universities' Transport Study Group (UTSG) and the Knowledge Transfer Networks (KTN) to help maximise our reach for these events.
- Engagement with funding bodies such as Innovate UK, UKRI and its research councils as well as learned societies such as The Royal Academy of Engineering, the Institute of Engineering and Technology (of which DfT is a corporate member), the Institute of Civil Engineers and the Royal Society.
- Through the members of the Transport Research and Innovation Board (TRIB) who influence the R&D conducted by DfT's Arm's Length Bodies (ALBs) and the wider transport R&D sector, and the DfT Science Advisory Council (SAC) who have considerable reach and standing throughout the transport industrial and academic communities.

Role of DfT Arm's Length Bodies

1.14 DfT Arm's Length Bodies (ALB) are a critical element to the effective delivery of our policies. They also have their own considerable research and development budgets which are devolved from the department. DfT and ALB's work closely together to understand each other's challenges, R&D priorities and identify synergies, along with attendance at ALB's research and innovation boards. However, their evidence and research needs are not captured by the DfT ARI as they have their own processes for engaging the community. To find out further details on the key research areas for each ALB, we encourage the community to use the below links and make contact:

Name	Contact
Driver and Vehicle Licensing Agency	DVLA
Driver & Vehicle Standards Agency	Research at DVSA
Highways England	Innovation portal
High Speed Two (HS2) Limited	HS2 Contact
Office of Rail and Road	ORR contact
Maritime and Coastguard Agency	MCA
Network Rail	Research Development and Technology
Vehicle Certification Agency	Get in touch

Table 1 How to contact ALBs

Work with us

1.15 We welcome contact from across the transport landscape in the UK and beyond to discuss opportunities to work together on our research interests. We invite you to contact the 'Bridge To Research' mailbox [BridgetoResearch@dft.gov.uk] and we will ensure you are put in contact with the relevant policy leads. The address is not for any queries relating to open procurements, research competitions or seeking funding from the department.

1.16 We welcome and encourage contact from everyone in the research community, including those from unrepresented groups, to ensure our research and evidence base is representative of the population we serve. Diversity in perspectives will help us achieve more innovative ideas, more quickly, and better equip the transport system to be able to meet the diverse needs of its users.

1.17 We also encourage you to contact your academic institution's knowledge broker (or industrial equivalent) if you're unsure of whether your work would be of interest to policy makers. For example, by using the contact details listed for members on the Universities Policy Engagement Network (UPEN) site.

2. DfT's Strategic Priorities

2.1 DfT supports the transport network that helps the UK's businesses and gets people and goods travelling around the country. Transport is fundamental to where people live, where they work, where they socialise; it is an essential enabler of business. We plan and invest in transport infrastructure to keep the UK on the move.

2.2 We have identified five Strategic Priorities which sit at the heart of DfT decision-making and the plan for achieving these priorities is outlined in the Department's Outcome Delivery Plan.

2.3 DfT's Strategic Priorities are:

- **Grow and Level Up the Economy:** Improve connectivity across the United Kingdom and grow the economy by enhancing the transport network, on time and on budget.
- **Improve Transport for the User:** Build confidence in the transport network as the country recovers from Covid-19 and improve transport users' experience, ensuring that the network is safe, reliable, and inclusive.
- **Reduce Environmental Impacts:** Tackle climate change and improve air quality by decarbonising transport.
- **Increase our Global Impact:** Boost our influence and maximise trade by having an innovative outward-facing approach.
- **Be an Excellent Department:** Be a well-run department that focuses on delivery, demonstrating excellence in transport policy, driving value for money, and embodying our values in all that we do.

2.4 Research and all the evidence types detailed in 1.10 are crucial to underpinning and driving progress against these priorities, enabling us to generate and measure tangible benefits to people and places. DfT needs rigorous, robust, relevant and timely evidence so that the Department can design and deliver policies to achieve its Strategic Priorities.

2.5 As a consequence, our research questions map directly to three DfT Strategic Priorities, 'Grow the Economy', 'Decarbonise Transport', and 'Improve Transport for the User' as summarised below. Some research themes, such as geography, social structure, demographics and technology, cut across our objectives. For the sake of brevity, we do not repeat these themes throughout, but only refer to them in those areas where we think it is particularly important to focus on them.

2.6 Our strategic priority to 'Increase our Global Impact' sets the context for all that we do in the Department. Through all our research we aim to boost our influence internationally and export our expertise and talents in alignment with the Prime Minister's ambition of being a Science Superpower. We believe there is potential for transport to be a UK flagship sector. We also seek to maximise trade by having an innovative, outward-facing approach. Partnerships both domestically and internationally are critical to our success, and we will therefore look to partner with like-minded nations to leverage investment, share burden and accelerate our own adoption of new thinking. Although not presented with any specific evidence or research needs, we have international elements across all three highlighted strategic priorities.

2.7 Our strategic priority of 'Be an Excellent Department' drives the way DfT works and determines the way in which we work to deliver our policy objectives using the extensive evidence base developed by the ARI and other methods. It drives our vision of embodying our values in all we do and all our interactions. Being a well-run department and adopting a culture of proportionate monitoring and evaluation extends to the work we commission externally and provides the evidence for delivering value-for-money for the taxpayer.

2.8 Our strategic priorities cannot be delivered without effective supportive processes, technology and people, in a way that works collaboratively with our partners and focuses delivery. Working closely and productively with the wider transport research community is an important part of this ambition.

3. Grow and Level up the Economy

Improve connectivity across the United Kingdom and grow the economy by enhancing the transport network on time and on budget

Context

3.1 Government is committed to 'levelling up', so that every corner of the country can benefit and share in future prosperity. Transport connectivity is an essential input into the efficient functioning of markets, reducing the costs of doing business and supporting linkages between key sectors of the economy. More efficient and faster delivery of major projects are fundamental to job creation and so a key lever for economic growth and our recovery from Covid-19. We are therefore enhancing the national strategic transport network, shifting the focus of DfT investment towards major projects that link the towns, cities and left behind places outside of London and the South East.

3.2 Key areas of focus are:

- More productive cities and towns
- Support local growth and regeneration
- Support jobs and skills
- Improve networks between major economic centres, and with international gateways
- Strengthening the Union

3.3 Delivery of major programmes such as HS2, the Integrated Rail Plan, TransPennine Route Upgrade, the Williams-Shapps Plan for Rail and the Roads Investment Strategy are fundamental to job creation and a key lever for economic growth and our recovery from Covid-19. Further commitments are outlined in the UK R&D Place Strategy which is being published this year as part of the UK R&D Roadmap. The research and evidence needs set out below are critical to supporting DfT deliver these major programmes and key areas of focus to grow and level up the economy.

Research and evidence needs

Strategic issues

1. How can we determine what economic and societal issues are best solved with infrastructure and engineering, and which might be solved by other means e.g. digital connectivity and land use?

2. What type of transport interventions are most effective from an economic stimulus / job creation perspective? Has the role of transport in economic growth changed with increased digital substitution for transport?

3. How can we build more effective regional networks outside London, ensuring quality transport connections to enable those areas to function as economic clusters and reduce the cost of doing business?

4. To what extent do we have evidence on the impacts of transport investment on specific areas such as the spatial distribution of productivity or social mobility and inclusion?

5. How can the social and economic disparities from the impact of the Covid-19 pandemic be mitigated through transport investment schemes?

6. How will societal and economic changes vary regionally and how will they affect the financial health of the transport system? What do these changes mean for the funding model of public transport? Will a fundamentally different approach be required to funding public transport?

7. How do different models of funding, planning and decision-making result in different outcomes for transport e.g. centralised vs. devolved; public vs. private operation of networks/asset management; short vs. long-term?

8. How can the transport network play a role in strengthening and improving connectivity between the four nations of the UK?

9. What are the benefits and barriers for devolved transport policy? How do we build on our current devolution policy to further maximise effective working practices?

10. How can we generate new jobs, provide support for existing British industries, and open new opportunities for the development of new skills and technologies?

11. How can government intervention promote UK trade and exports?

12. To what extent has the UK's competitiveness in transport infrastructure changed relative to other countries? And what lessons can we learn from short-term changes internationally that can be implemented long-term domestically? For example, how has UK's transport World Economic Forum (WEF) Competitiveness Index scores increased/decreased compared to other countries?

13. How do we best encourage innovation in our transport system and transport technologies? What is the relative efficacy of market led innovation compared to innovation led by central government funding? How can government R&D interventions best support SMEs progress through their growth pathway?

14. What are the strengths and weaknesses of interventions used to stimulate innovation by other governments around the world?

15. What will be the appetite and ability of future transport sectors to invest in innovation/R&D?

Local connectivity, growth and regeneration

16. How can we accelerate projects that support the regeneration of left-behind towns and places, and increase local productivity and connectivity through improving transport linkages within local economies?

17. What role can transport play in levelling up left-behind places in the context of changing travel/commuting patterns?

18. What is the relationship between transport improvements and local economic growth?

19. What conditions need to be in place for transport investments to transform local economies? These conditions may relate to demographic factors, complementary investments or government policies for example.

20. How can we invest in rail, cycling, walking and an improved bus network to improve connectivity within small towns and cities, and enable access to economic opportunities by connecting people with employment centres and key services at a local level?

21. How can we target improvements for longer term resilience and ensuring that the fastest movement of the most people is prioritised by delivering bus priority infrastructure and cycling links?

22. Where have bus services been a success (either in the UK or internationally) and why were they successful? How is it related to history, socio-economic and demographic factors, alternative travel modes and financial and other incentives?

23. How does the capability and capacity of Local Transport Authorities influence the delivery of transport policy developed by central government?

24. What are the best policies, interventions, and strategies to improve the capacity of local authorities to deliver transport provision?

25. What are the impacts of transport schemes that facilitate housing developments (such as urban realm)?

26. How can transport investment release additional land for housing and deliver wider economic benefits?

International connectivity

27. How important is transport to trade flows? How might international trade evolve and how might this affect our transport network requirements?

28. How can aviation and maritime best facilitate trade?

29. How has Covid-19 impacted the financial resilience of UK aviation companies as well as the wider aviation supply chain, and what impact will this have on the Government's strategic objectives? Have these impacts modified the market structure or associated labour markets? What are the impacts of existing and potential Government support measures?

30. How should the way airports slots are allocated be reformed to make more efficient use of constrained airport capacity and support achievement of the Government's wider objectives?

31. How can we develop a more detailed understanding of the benefits that modernising UK airspace will bring, including carbon reductions, noise impacts, reduced delays, increased resilience and increased capacity to allow for growth?

32. What is the economic value of the different parts of the aviation sector, including 'general aviation', and what Government intervention will enable the sector to support innovation and skills development as the "grass roots" of the aviation sector?

33. How can we improve the provision of information; set standards; and use new technologies to improve aviation safety and security?

34. What will be the impact on maritime and shipping infrastructure, skills and careers as international trade evolves? What are the opportunities for UK coastal shipping?

35. How can we best support and grow the UK Maritime Sector, innovation in maritime and potential related green jobs? What roles do maritime sectors play in the wider productivity of the UK economy?

36. What works in terms of increasing the diversity of people choosing maritime careers? Which are the most valuable and transferable lessons from other STEM led sectors in identifying barriers and solutions to make maritime careers highly desirable for all?

37. How can we improve modelling of UK port activity and the impacts of possible policy measures on the maritime sector?

38. How do we ensure UK continues to be recognised as the global leader in maritime safety? What is the safety culture in the industry as it stands?

39. What are the key disruption risks to UK maritime? What are the most effective mitigations at the local and global level to ensure the safe and reliable passage of goods and passengers to, from and around the UK?

40. What is international maritime best practice and precedent for wreck retrieval?

41. On waterlogged munitions (including the SS Richard Montgomery), how do we best monitor underwater conditions of munitions?

New and emerging technology

42. Which innovations present the greatest value and which might be disadvantageous to the transport system? Is it possible to map Technology Readiness Level (TRL) with potential positive impact and user adoption?

43. Are there further opportunities to explore retrofit technology beyond the bus market?

44. Could autonomous vehicle shuttles be used on legacy transport, such as a replacement for closed rail lines?

45. How will new and emerging technology assist in reducing construction costs for road schemes?

46. What are the definition and groups of new and emerging aviation technology? How will or could new and emerging aviation technology change travel patterns and demand, and fit in with the wider future of transport scenarios of seamless connectivity and living local?

47. How can drones and other new technology be used safely and securely to open up new opportunities; develop new markets; and deliver aviation services to realise their full potential in the UK and to deliver economic growth?

48. How can we utilise space-based technology to support and improve the transport system?

49. How is spaceflight in the UK developing and what evidence exists to inform DfT's role in the National Space Strategy?

50. What is the potential for commercial human space travel in the long-term?

51. What are the most relevant emerging technologies for maritime and shipping (e.g. autonomous vessels)? What are the risks and opportunities for the UK across economic, social and environmental dimensions?

Analysis, modelling and prediction of transport demand

52. What are the economic and societal impacts of potential lower service levels?

53. What role could the theory underpinning social welfare functions play in analysis associated to the Government's levelling-up agenda? What role could new census data play in the analysis of levelling-up?

54. What are the micro mechanisms that underpin how workers move across space due to better transport connections?

55. How can we better capture the impacts of transport, including improvements to the appraisal of active modes, freight, and values of time in congested conditions and how these vary for different groups?

56. What new environmental techniques should be utilised in the analysis of road schemes that are not currently set out in Transport Analysis Guidance?

57. How can we better monitor and evaluate the impacts of road schemes, and other large-scale infrastructure projects, on cultural heritage sites and their users?

58. How should the lifespan of a new road enhancement be measured?

59. Are the modelling techniques used in appraisal current and robust? Is this reflected in the department's guidance and tools that it provides to users?

60. How do standards in appraisal and modelling practices of road schemes in the UK compare to international practices?

61. What needs to be true of demand modelling for the estimates produced to capture long run changes in demand for road schemes that may change the spatial distribution of economic activity? To what extent do estimates from conventional user benefits approximate the total welfare impacts of transport schemes on users, considering the impacts of changing land use?

62. How will new and emerging technology change travel patterns and demand on the Strategic Road Network?

63. How can we best develop the uncertainty tools and products referenced in the Uncertainty Toolkit? These will primarily be publication of the common analytical scenarios in TEMPro, the revision of TAG Unit M4 and improving future proofing decision making processes and their guidance across the department.

64. What are the future scenarios for demand at UK ports and how might the behaviour of passengers and freight users change over time?

65. What are the long-term drivers for aviation demand as we recover from Covid-19 and are they different from pre-pandemic drivers?

66. What evidence is there of the value of Government or transport operator investment in transport data assets or data projects?

67. What is the evidence of the emerging use and impact of novel/real time data sources to address transport issues at local or national levels, such as decarbonisation and levelling up?

68. What does recent data tell us about possible long-term demand for private cars, electric vehicles, carpooling or public transport as a substitute and how might this impact decarbonisation?

69. What is the best way to maintain and develop the software suite that supports the development of business cases, such as Transport Users Benefit Appraisal (TUBA) and Wider Impacts in Transport Appraisal (WITA)? What is the best avenue to communicate the Department's methodologies to stakeholders?

Freight and logistics

70. How has the delivery of goods changed and what is the impact of this?

71. How is freight demand likely to change in the future? What impact will reduced transport costs of delivery have?

72. How easily can freight capacity shift between types of goods and different transport modes?

73. What is the market structure of the road haulage market and how has its structure and competition in the market changed over time?

74. How have road haulage businesses responded to economic shocks such as the 2008 financial crisis, Covid-19 and EU exit? How resilient are businesses for the future?

75. Where freight businesses face difficulties in accessing finance, how is this evidenced and what alternatives are there?

76. What are the characteristics of the HGV labour market and how has this changed over time? What is the wage elasticity of labour supply and what factors affect this?

Dangerous goods

77. What is the best method to assess the resilience of tank vehicles, tank waggons, portable tanks and tank containers under conditions representative of typical impact situations?

78. What is the best method to inspect traditional and modern joining methods to identify flaws that could compromise the safety of tanks constructed using such methods?

79. How could modern materials and construction techniques be used to improve both the safety and, through weight reduction, the productivity of dangerous goods tanks?

4. Improve transport for the User

Build confidence in the transport network as the country recovers from Covid-19 and improve transport users' experience, ensuring that the network is safe, reliable, and inclusive

Context

4.1   We must put the needs and expectations of current and potential users at the heart of the operation of the transport system, especially given the significant impact Covid-19 has had on both usage and perceptions of public transport. Ensuring that our infrastructure and the services which use it meet the varied needs of businesses and the public, are attractive, affordable, sustainable and resilient is a crucial goal for the department.

4.2   Key areas of focus are:

- Building confidence and improving the public transport experience
- Improving the experience for road users
- Building a transport network that works for everyone
- Continually improving the safety, security and resilience of the transport system

4.3   The research and evidence needs listed below are integral parts to help deliver our key areas of focus and address how we make progress against initiatives such as the National Bus Strategy, William-Shapps Plan for Rail, and the Inclusive Transport Strategy. This is more important than ever as the risks from COVID-19 reduce, people build the confidence to return to public transport and new travel patterns emerge. Social and behavioural science and research is core to the delivery of all our programmes, including R&D. This is critical to ensure the development and delivery of policy includes the needs of all groups, especially those often marginalised.

Research and evidence needs

Building confidence and improving the public transport experience

80. What are transport passenger's priorities and drivers of satisfaction in 2021 and beyond, across all forms of transport? What will represent good value for money?

81. Beyond speed and cost, what aspects of transport journeys do people value?

82. How do people perceive reliability, punctuality and variance in journey time?

83. How can new technologies, digitalisation and data analytics be utilised to improve transport networks, user experience and create more effective and cost-efficient transport systems?

84. Do emerging technologies in tracking human experience provide valuable insights? What are the strengths and limitations of activity tracking, eye-tracking, heart rate, bio-markers, neurological sensors?

85. How can we embed better evidence into our investment decisions, the impacts of investment on transport users and communities (including vulnerable and protected groups)?

86. How has the introduction of new technologies such as micromobility impacted transport users and the requirements of the broader transport system?

87. What journey-related mobile connectivity needs do passengers have now and in the future? How best can these needs be met, and what role could government play to support delivery of these outcomes?

88. How can technologies such as demand responsive transport (DRT) and bus rapid transit (BRT) support the delivery of effective bus services?

89. What are the potential benefits of Mobility as a Service (MaaS) and why is it not more widely deployed yet? What are the barriers to MaaS systems developing and what should Government be doing about this?

90. How can we best use passenger charters & passenger representation to improve standards of service and improve passenger experience for aviation?

91. What are maritime passenger views and experiences on board ferries, accessing to ports, passenger safety perceptions and confidence to travel?

Road safety for users

92. What is the relationship between road safety interventions, including enforcement and reductions in casualties and killed or seriously injured (KSI)?

93. What would happen to casualty trends if there were no policy interventions?

94. Which road safety interventions have had the greatest impact on casualties in recent years?

95. Which policies and interventions have the greatest potential to reverse the lack of progress in road casualty reduction since 2010?

96. How we can reduce casualties when there are greater numbers of more vulnerable older adults using our roads? How can we enable greater numbers of older people to stay safe on our roads? How can and should existing interventions be adjusted to cater for an ageing population?

97. What injuries are sustained by road users in collisions and how can the information be used to improve the safety of new vehicles?

98. What are the most effective ways of improving the safety (and perceptions of safety) of cyclists and pedestrians (particularly, child and older adult pedestrians who are at greater risk)? How should DfT work with external organisations to support these interventions?

99. How does the use of telematics improve road safety and how can it be used to encourage both safer and more fuel-efficient driving?

100. What are the implications (for both safety and insurance) of people continuing to drive with high numbers of penalty points or immediately after serious offences (as only the courts can disqualify someone from driving)?

101. What is the feasibility, benefits and road safety risks of relaxing driving licence regulation and training qualifications so people can drive certain heavy vehicles with less additional testing or professional development?

102. What are the risks associated with new vehicle lighting technologies and can these be mitigated? What are the risks and benefits of allowing the use of red flashing lamps by road recovery operators?

103. What are the practical benefits and are there and risks associated with allowing HGV platooning on the UK strategic road network?

104. How can we reduce the risks faced by motorcyclists, who are the most vulnerable to death on our roads? What role can the use of personal protective equipment have (including innovations in this equipment) in reducing the risk of serious injury and death amongst motorcyclists?

105. How can information on the safety of motorcycle helmets and new cars be used to assist consumers to make better choices and choose safer products? Which regulatory compliant motorcycle helmets and cars on the UK market offer the best, and which offer the poorest levels of safety in the event of a road collision?

106. What are the needs of road users, and how can existing and new traffic systems be utilised/ developed to respond to these needs?

107. How does the introduction of new transport technologies affect user experience of the transport networks? Are the changes in alignment with the Department's objectives? Are traffic standards and guidance still appropriate and relevant considering technological and environmental changes?

108. How can we best share the research being conducted on traffic technology investments with the wider community?

109. What are the implications of international vehicle standards for safety and the environment and how can these inform Free Trade Agreement negotiations and the development of the GB type approval scheme?

110. How can we promote efficiency and innovation in the maintenance and management of our roads?

111. What are the strengths and limitations of advanced and emerging vehicle designs and technologies, from personal electric vehicles through to automated shuttles, and how can we enable their safe and secure use on roads?

Transport Accessibility

112. How can we invest in transport accessibility and inclusivity to ensure we build a transport system that works for everyone?

113. What is the lived experience of users of transport based on protected characteristics; gender, age, ethnicity, physical & mental disability? How do these categories interact? How will future transport demand vary in different demographic groups?

114. How can we ensure the safety of women when travelling on transport and improve the perception of the risks of travelling?

115. What are the passenger experiences for those with physical and hidden accessibility needs using airports and planes?

116. Do passenger experiences and/or perceptions prevent people with disabilities from using maritime modes (ferries and cruises)? What areas of the passenger experience that are problematic for people with all types of disabilities?

117. How can we support UK innovations which boost accessibility of transport to deliver growth as well as making transport more accessible around the world?

118. What digital and cashless payment methods are feasible on different modes and services including bus, coach, metro and train and how do we minimise exclusion during a transition?

Continually improving the safety, security and resilience of the transport system

119. How can emerging technologies be deployed in a safe and secure way to enhance the protective security and resilience of transport systems?

120. How can the risks that emerging technologies pose to transport systems be identified and quantified?

121. How can innovations in data science, data analytics, sensor technology (including innovative deployment) be used and integrated with wider security systems to enhance security in transport systems?

122. How can new approaches and technologies be applied to enhance the detection of threat materials and items that could harm transport systems?

123. How can new approaches and technologies be applied to perform targeted screening of specific areas of the body?

124. How can new approaches and technologies be applied to perform targeted screening of groups of people?

125. What are the evolving risks to transport posed by the malicious or negligent use of drones?

126. How can new approaches and technologies be applied to deter, detect and disrupt the misuse of drones?

127. How can public messaging on transport systems be used to best effect to safeguard transport users following a security incident or natural hazard disruption?

128. How can throughput of goods and people be increased cost-effectively through transport security systems?

129. How can the quality assurance of security systems and processes be improved?

130. How can models be used better to understand and respond to security and resilience risks regarding transport systems?

131. What will be the impact of climate change on transport infrastructure, and how can we make our transport infrastructure resilient to a changing climate?

132. Which new technologies and approaches can be applied to improve transport systems resilience to disruption from natural hazards?

133. How will future global trends such as climate change and biodiversity loss impact the security and resilience of UK and global transport systems?

134. How can new technologies and approaches be applied to enhance the cyber security of transport systems, including points of interconnection, autonomous transport and commercial space flight? How does increased cyber-reliance in transport systems reduce our resilience to or increase the impact of an attack or major catastrophe?

135. How do we prepare for, and respond effectively to, emergencies and unexpected events affecting transport? When incidents and disruption do occur, how do we keep people informed and resume service as quickly as possible?

136. What are the options for reducing our reliance on space-based Position, Navigation and Timing (PNT) systems? What is the most cost-effective way of ensuring adequate resilience and redundancy of PNT across transport systems?

137. How can we improve and increase the resilience of data, communication and position, navigation, and timing connectivity of transport users?

Covid-19 pandemic

138. How will public transport confidence be affected as lockdown eases and use increases? What are effective techniques to reduce public transport hesitancy?

139. What level of social distancing is required on public transport, given varying ventilation levels and potential for more transmissible strains of Covid-19? What mitigating factors can we continue to encourage use?

140. How will behaviour on public transport be affected by a lack of ability to social distance? Will users experience and respond to crowding in the same way?

141. What does safe transport mean to passengers post-Covid-19?

142. What can be learnt from experiences during Lockdowns that informs future transport investment?

143. What are likely to be the main barriers to public transport use in a post pandemic context and how can these be overcome?

144. What research methods are capable of estimating which users are not travelling, since the introduction of Covid-19 restrictions? Which journeys might be being foregone or replaced?

145. How would people respond to future 'stay home' travel restrictions if they were re-introduced? What behaviours would be repeated and what would change?

146. What has the overall impact of Covid-19 been on sustainable travel behaviour?

147. What structural design changes can be made to vehicles/infrastructure approaches to reduce the transmission risks of future pandemics and increase resilience? What interventions could we make if a contagious agent was present which tends to spread through mechanisms different to those seen in Covid-19 which spreads via droplets and surfaces?

148. What level of safety and assurance do vulnerable users require in order to return to using public transport since Covid-19 restrictions have been lifted?

149. What factors act as barriers or facilitators to travel for people with disabilities and what impact has Covid-19 had on this? What is the relative effectiveness of interventions to reduce barriers to travel and how can we best measure the value of interventions to increase the accessibility of transport?

150. How are consumer and business attitudes towards international travel changing in the post-pandemic world and how will their behaviour evolve? How can we motivate compliance with testing and isolation requirements in order to unlock international travel safely?

151. What are the factors affecting consumer confidence in international travel following the pandemic and how can Government best develop policies to improve consumer confidence?

152. How would a shift in preference for more spacious homes change the demands on the road and public-transport systems?

153. How would an increasing demand for outdoor space affect transport? How would transport design adapt to changing preferences for outdoor seating?

154. How might Covid-19 affect the second-hand vehicle market in the future?

Social and behavioural science

155. What is the impact of trends in key societal and economic changes on the future transport system? Including travel patterns, working from home, attitudes to the high street, the distribution of population i.e. dispersed vs concentrated living decisions. How do these changes affect the demand for transport and how have the needs of the user changed?

156. How will long-term patterns of commuting and working from home affect travel behaviour and travel demand and how do these vary by geography and demographic characteristics? Are there any realistic levers or interventions that are proven to work in encouraging more sustainable travel?

157. How can we ensure technologies and technology-based services are both developed around users and realise their wider social and economic benefits? Including autonomous vehicles; Mobility as a Service; new shared services; new business models for car ownership; and the use of data in transport.

158. What are the best ways we can support the opinions ensure the views of non-users and vulnerable groups are properly understood and built into the planning and design of to new forms of transport such as e-scooters and connected and autonomous vehicles? How can we ensure that changes to transport (for example through e-scooters and autonomous vehicles) are realised safely?

159. How can behavioural science be applied to enhance the capability and capacity of transport system workers to deliver improved security outcomes and transport experience?

160. How can behavioural science be applied to deter, detect, and disrupt terrorists using or targeting transport systems?

161. What are seafarer's attitudes towards safety on board, reporting damage or faults, wearing of PFDs, and motivations towards a safety-first culture on board?

New and emerging technology

162. How can existing UK transport regulation be made more flexible for innovators yet retain appropriate Government controls to ensure good outcomes for safety, the environment and passenger experience?

163. What are the benefits and risks of new and emerging aviation technology (e.g. unmanned aircraft, advanced air mobility, low carbon flight etc.) to transport users?

164. What are the options and new technologies to detect and improve enforcement against vehicles with high noise emissions?

165. How will new and emerging technology assist in the operation, maintenance and renewal of the Strategic Road Network?

166. How can we use the internet of things / remote sensors to improve the transport system? What are the key use cases now and for the future, what prerequisites must be in place to support such solutions?

5. Reduce Environmental Impacts

Tackle climate change and improve air quality by decarbonising transport

Context

5.1   Transport is the largest emitting sector of greenhouse gases (GHG) in the UK, contributing 27% of domestic emissions in 2019. Our transport system must change to deliver the Government's Net Zero ambition and DfT will drive forwards that change through our longer-term green transport agenda. Sustainability will be at the heart of levelling-up. People everywhere will feel the benefits - villages, towns, cities and countryside will be cleaner, greener, healthier and more prosperous and pleasant environments in which to live and work.

5.2   Key areas of focus are:

* Decarbonisation of road vehicles
* Accelerating modal shift to public and active transport
* Decarbonising how we get our goods
* Place based solutions and environmental impacts
* UK as a hub for green transport, technology and innovation
* Reducing carbon in a global economy

5.3   The Transport Decarbonisation Plan (TDP) sets out the steps we will take to deliver the necessary carbon reductions across every form of transport. DfT's progress towards a decarbonised transport system has a vital role in delivering net zero across the wider economy by 2050 and science, engineering, innovation and research are essential in driving this change.

Research and evidence needs

Decarbonisation of vehicles

167. How can we support a technology transformation to eliminate all vehicle exhaust emissions before 2050?

168. How can we support drivers and vehicle manufacturers during an ambitious phase-out plan for the sale of new petrol and diesel vehicles?

169. What are the real-world pollutant emissions of road vehicles, including non-exhaust emissions, and what are the technologies that can be used to reduce them?

170. How can nitrogen oxides (NOx) emissions of hydrogen internal combustion engines (ICE) technologies be minimised and what is the lowest it could be?

171. How much ozone do electric vehicles produce from their motors and from pantographs (collectors of charge from overhead wires)?

172. What future electric vehicle charging technology will be available? What are the advantages and disadvantages? And what groups of electric vehicle users will it mostly benefit?

173. There are a number of barriers to increased electric vehicle uptake including range anxiety, charging anxiety, price and other factors. Which of these factors are most important to consumers and how does this vary by different subgroups of consumers e.g. low income households, rural or urban households, those in different accommodation types? Does range-anxiety lead people to over-specifying or delaying in investing in an EV? Can communications, education and technology reduce range and charging anxiety?

174. What is the potential for battery recycling and how can this potential be reached?

175. What are the factors that affect electrified vehicle battery performance and degradation? What are the methods for assessing battery health?

176. How does user behaviour affect the environmental impact of Internal Combustion Engines (ICE), Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV) and Battery Electric Vehicles (BEV) including driving, storage, maintenance and fuelling or charging?

177. How does climate and topography of route affect performance of buses powered by batteries?

178. Will 'vehicle to grid' reverse charging impact on electric vehicle battery life?

179. How are EVs changing the nature of the 'kerbside'; what technologies are available to meet the needs of parking, charging, home-deliveries, rideshare pick-ups/drop-offs, pedestrian and cycle lanes?

180. What is the best way to solve the issue of charging for those without off-street provision?

Decarbonising how we get our goods

181. How much can freight be decarbonised through efficiency and sharing in advance of deployment of ZE technologies like hydrogen and battery-powered HGVs?

182. What is the potential market and benefits (emissions savings, fewer journeys, etc) from longer and heavier vehicles (>44 tonnes GVW) and how do we manage technical concerns and safety risks?

183. What is the most effective way to decarbonise domestic freight – from port, airport or rail freight hub to door? What are the barriers to deployment and how can these be overcome?

184. How effective are current Local and Central Government planning systems and planning officers in shaping the efficiency and environmental impacts of road freight and what future improvements may be needed, including to capability, to ensure the planning system supports road freight to contribute to meeting Government ambitions?

185. What environmental and logistical improvements, including those related to road freight emissions, urban air quality and congestion, could we expect to see if the planning approval decision making process were more technocratic and gave more weight to wider improvements?

186. What approach should central Government take to best manage and organise road freight / logistics in the UK to make it more efficient, resilient and reduce its environmental impact and what would be its likely impact on costs and competition in the supply chain?

187. How can we decarbonise the last mile through new delivery models and technology, supported by digitalisation?

188. How can rail and domestic maritime be used to contribute to zero carbon modes of transporting goods and services?

Decarbonisation of international connectivity and the global economy

189. How can we lead the global economy in aviation and shipping to decarbonise these industries?

190. What are the relative merits of existing, emerging and future technologies in helping to decarbonise aviation?

191. How can we best support the scale up of the Sustainable Aviation Fuel (SAF) industry and DfT's chosen strategic ambitions for the UK SAF sector?

192. How can policy action best support decarbonisation of aviation? What is the most appropriate role for market-based measures compared to other policy measures? How should market based measures and other policy measures be designed to mitigate the risk of unintended consequences?

193. What evidence exists to enable the DfT to further enhance its ability to forecast aviation GHG emissions and model the impact of potential policy action?

194. How will new and emerging aviation technology such as unmanned aircraft, advanced air mobility, low carbon flight, provide environmental benefits or disbenefits and what environmental assessment techniques should be applied?

195. How can maritime and shipping contribute to the UK goal of net zero GHG emissions by 2050 and the goals of the UK Clean Air Strategy, while capturing the green-growth potential?

196. What are the most cost-effective measures for reducing shipping emissions both domestically and internationally?

Place based solutions and environmental impact of transport

197. How do we create place-based solutions so that every place in the UK will have its own zero emission transport network before 2050?

198. What can we learn from place-based interventions and what works and does not work and why in different areas?

199. How can we reduce the impact of the transport system on biodiversity?

200. What is the role for local and national planning in minimising the environmental impacts of the efficient movement of people and goods?

201. How are the local environmental impacts of aviation evolving through time (e.g. noise and air quality) and how can they best be mitigated?

Accelerating modal shift to public and active transport

202. How can we make public transport and active travel the natural first choice for daily activities?

203. What is the relative effectiveness of different incentives to promote active travel?

204. How much does journey time matter when choosing between public and active transport? Are there social interventions that could make public and active transport travel the preferred choice when there is a faster alternative?

205. What are the key behavioural influences (either drivers or barriers)? How do we encourage active travel when the weather is poor?

206. How much does active travel for recreational purposes lead to people using active travel for work and other non-recreational purposes?

207. Do people who switch to active travel see benefits in broader health and wellbeing? Can longitudinal research establish or disprove a connection between outcomes?

208. How and why has the trend in the number of walking trips changed over time? What can we expect in future?

209. How can we create a cohesive, connected and integrated zero emission public transport network that will empower users to make sustainable end-to-end journeys?

210. How could data-driven business models for transport facilitate modal shift towards mass transit and active/other low carbon travel modes?

211. Why do other countries have higher levels of cycling? How is it related to history, socio-economic and demographic factors and financial and other incentives? What is the role of culture in facilitating / obstructing shift towards active travel (and particularly cycling)?

212. How can we encourage those who have begun walking and cycling more during the pandemic (when traffic levels were lower) to feel safe as traffic levels return to normal?

213. What are the whole-life carbon costs of e-scooter schemes once supply chains, maintenance and other secondary sources of emissions are taken into account?

UK as a hub for green transport, technology and innovation

214. How can the flexibility of the energy system be maximised?

215. What elements of a mature hydrogen supply chain are missing in the UK? Where do we have the ability for supply chain, but not the capacity?

216. What role could green hydrogen play in a fully decarbonised transport sector? What are the 'no regrets' steps we could take now, the key barriers and how can they be overcome? When will green hydrogen be able to be used in significant quantities in transport for relevant modes?

217. How do we encourage take-up and make best use of the various approaches to hydrogen generation as an intermediary in transport until the price of green hydrogen is economically viable/ until green hydrogen is produced in sufficient quantities to supply relevant transport markets/ modes? What may be the barriers associated with these various approaches?

218. What are the opportunities and constraints for maximising carbon savings from low carbon fuels across different transport modes? This could include in-depth research into potential future feedstocks and their competing uses across the economy or how existing infrastructure might need to be adapted for future production and distribution.

219. How can the UK make best use of existing zero emission technologies and fuels?

220. How can the UK pioneer new powertrain technologies across the transport sector, including hydrogen; embrace innovation and capitalise on new industrial opportunities?

221. How does the UK play a leading role in this modern-day industrial revolution and consolidate our position as an internationally recognised leader in green technology, science and research?

222. How can UK-based innovators scale up and export efficient business models, creating regional and global leaders?

223. Could the rail network be used to distribute hydrogen across the country?

Social and behavioural science

224. How can behavioural science be used to encourage people and organisations to make more sustainable travel choices?

225. How can people's travel behaviour be made more sustainable? What is most flexible?

226. Do the activities of high-emitting travellers undermine the perceived effectiveness of the average transport user?

227. How do people think about their environmental transport footprint? Are their perceptions of carbon emissions for different journeys accurate? What role does local air quality play in sustainable transport perceptions?

228. How can we benchmark public perceptions on the use of hydrogen in transport and how do we move public perceptions of its safety as we migrate away from a kerosene-based supply chain?

229. What are the net emissions effects of changing travel patterns such as in-person to online shopping, commuting to working from home, car use and use of local services?

230. Would presenting trip estimators showing the carbon cost of a trip compared to alternatives affect travel choices positively or negatively?

231. Which demographic groups are most car reliant? And which are public transport reliant? How do we get demographic groups which are high in car reliance to be less dependent, for example in rural areas?

232. How can we encourage more sustainable and efficient use of cars and roads? What are the most effective interventions to reduce car use, car reliance and congestion?

233. What steps would be most effective at increasing car occupancy?

234. Would displaying the lifetime running costs and whole-lifecycle emission impacts affect car purchase/leasing behaviour?

235. What role does international travel play in people's understanding of their personal transport footprint? How do people think about occasional large-emitting activities versus day-to-day small changes?

236. How will consumer preference and demand for sustainable modes and products develop?

237. What are the most effective ways that businesses can encourage sustainable travel? For example, what role can businesses play in helping to tackle carbon related to commuting?

238. What are the most effective and efficient low-cost ways to accelerate electric vehicle adoption?

239. What are the key drivers / barriers to consumers' adoption of technology that adds stability for the grid? How do these differ by consumer groups?

Annex A: Index of research and evidence needs by DfT Directorate Group

DfT Directorate Group	Reference of research and evidence need
Analysis and Science	2, 20, 43, 49, 55-56, 60, 64, 67-68, 70, 82-83, 85-86, 90, 114, 118-119, 132, 138-143, 145-149, 153-154, 158, 171-172, 177-178, 181-182, 200, 205-208, 214, 216, 224-233, 235-236, 239
Aviation	28-34, 47-48, 50, 66, 91, 116, 151-152, 164, 191, 193-195, 202
Environment and Future Mobility	44, 98, 103-104, 106, 110, 112, 144, 155, 163, 165, 170, 173, 175-176, 179-180 184, 192, 201, 211, 215, 217, 219, 234, 238, 240
Local and Regional Transport Analysis	8, 18-19, 23-24, 26-27, 89, 150, 203-204, 209, 212
Maritime	35-42, 52, 65, 92, 117, 162, 196-197
Rail	16, 45, 81-84, 88, 113-114, 119-122, 139-142, 144-145, 149, 167
Road Safety, Standards and Services	73-80,84, 87, 93-97, 99-102, 105, 107-109, 183, 185-187, 213
Strategic Roads, Economics and Statistics	46, 54, 57-59, 61-63, 72, 166
Strategy and Private Office	3-7, 9-17, 21-22, 25, 45, 51, 53, 69, 71, 81, 111, 113, 115, 136, 156-157, 159, 168-169, 174, 188-190, 198-199, 210, 218, 220-223, 237
Transport Security, Resilience and Response	120-131, 133-135, 137, 160-161

Table 2 Table listing which question was submitted by which DfT Directorate Group

NB Research and evidence needs listed may be of interest to other DfT Directorate Groups, other than the Group that submitted the question.

Annex B: Index of themes used to group research and evidence needs

Grow and Level up the Economy	Improve transport for the User	Reduce Environmental Impacts
Strategic issues	Building confidence and improving the public transport experience	Decarbonisation of vehicles
Local connectivity, growth and regeneration	Road safety for users	Decarbonising how we get our goods
International connectivity	Transport Accessibility	Decarbonisation of international connectivity and global economy
New and emerging technology	Continually improving the safety, security and resilience of the transport system	Place based solutions and environmental impact of transport
Analysis, modelling and prediction of transport demand	Covid-19 pandemic	Accelerating modal shift to public and active transport
Freight and logistics	Social and behavioural science	UK as a hub for green transport, technology and innovation
Dangerous goods	New and emerging technology	Social and behavioural science

Table 3 Themes used to group research and evidence needs