1. In this document, we will respond to a selection of the questions raised by the House of Lords’ Select Committee on Science and Technology from the social science perspective with which TSU and SPRU analyse large-scale transformations in societal systems such as transport. Our main argument is that, while connected and autonomous vehicle (CAV) technology has enormous potential and can be expected to have significant economic benefits to the UK, there are also important concerns about some of the gaps and omissions in the government’s approach to CAV technology:

- There is selectivity in the representation of the potential effects of investment in the development & production as well as the widespread adoption of CAV technologies. Anticipated economic benefits such as employment growth, productivity increases, inward investments and GDP growth as well as reductions in road congestion are given greater attention than other grand challenges UK transport and society more generally face – i.e., the need to increase physical activity, improve air quality and reduce greenhouse gas emissions, and concerns over social inequality. In all of these issues, everyday transport plays an important role, and widespread investment in, and adoption of, CAV technologies may be less effective in addressing these challenges than a fuller commitment by all levels of government from local to national scale to public transport, cycling and walking. The only potential social impact that is widely discussed is increased road safety, but evidence on this topic is disproportionately USA based. It is hence not immediately transferable to the UK where local transport is less car dominated and cars share roads with cyclists and pedestrians to a larger extent.

- More generally, the representation of economic and social benefits in government documents\(^1\) is overly positive and does not reflect the very large uncertainties about many of the potential effects of the widespread adoption of CAV technologies in transport.

- There is an absence of a long-term vision of the role of CAV technology within an integrated and efficient multi-modal transport system. The risk is that investments in CAV technology may cancel out some of the positive social and environmental effects of current and recent transport policies – including those funded by the Local Sustainable Transport Fund in the wake of the 2011 ‘Creating Growth, Cutting Carbon’ White Paper – have had, particularly at the local/urban level.

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Comprehensive future visioning is needed that considers the long term (e.g. 2040) and many different future scenarios, not only those assuming that CAVs will be symbiotic to, and complement, other forms of passenger and freight transport but also scenarios in which different types of conflicts and incompatibilities between different systems and investments are explored.

- The government’s approach is too strongly oriented at the supply side of technology and vehicle production and infrastructure development, rather than on the demand or user side. The role of citizens is largely limited to that of end-user and consumer, and other forms of agency – resistance, campaigning, etc. – and the motivations and concerns that may drive those are not given due attention. Not only should such motivations and concerns be listened and responded to in a liberal democracy, they can also complicate, delay and disrupt the development and diffusion of technological innovations. The history of innovation is full of examples in which linear narratives of expected expansion and progress (e.g. battery electric vehicles and genetically modified food in the late 1980-1990s) have turned out to be poor approximations of the developments that actually unfolded subsequently. Uncertainty is inherent to the development trajectory of any technological innovation. Yet, there is a large social science literature on the basis of which it can be expected that, for the case of CAV technology, actively involving the public in all stages of the innovation process – technology development, visioning about effects, changes to regulation, etc. – may help prevent some of the mistakes that have been made with other technologies in the past.

Below we offer more descriptive answers to the Committee’s specific questions.

What are the potential applications for autonomous vehicles?

2. CAV technology may be adopted for private, public and freight transport. To date, much of the government’s attention has been on the application of autonomous vehicles for private use. Yet there are a range of technologies specifically for freight and public transport that are being developed by traditional (e.g. Volvo, Daimler) and non-traditional (e.g. Otto, Starship Technologies, Peloton) companies. The potential opportunities and issues associated with automated vehicles in the context of inter and intra-urban freight, and public transport have attracted much less consideration in government policy and the public debate, and this requires attention to better understand how and where automated vehicles can contribute to the transport system.

3. Prior to considering application, it is also important to examine the scope of automated vehicles; what types of vehicles are in- and excluded. There is a wide diversity of automated vehicle technology ranging from small ‘pods’ (for both passenger and home delivery) to heavy goods vehicles. The ways these technologies use existing infrastructure, and demand alternative types of infrastructure, will vary substantially. For instance, automated delivery pods will use the pavement space with pedestrians and raise different questions to the use of HGVs on the UK’s motorway network.

4. In addition, there may be different applications and implications across the various stages of automation, which require greater clarification. For the freight industry, (semi-)automated vehicles may contribute to increased operational efficiencies (e.g. vehicle...
utilisation and labour savings) and reductions in fuel consumption (and associated emissions) in the short to medium term\(^2\). Nevertheless, research has suggested that environmental benefits of automated vehicles (e.g. potential reductions in energy consumption and emissions) are not assured, as they are not the consequence of automation, but rather relate to changes to the operation and design of vehicles and the transport system\(^3\). Wadud et al., for instance, report that low-levels of automation (semi-automated vehicles) may see energy intensity savings, particularly relating to vehicle connectedness, whereas highly automated vehicles may result in increased energy demand and travel activity\(^3\).

What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?

5. There is now a substantial literature and discourse on potential user benefits to private individuals, which focuses on greater efficiency, productive use of travel time, fuel cost savings and road safety.\(^1\)\(^4\) In addition, in other studies that have looked at how autonomous vehicles can be deployed to further develop the provision of mobility services (e.g. ride shares, car clubs), the benefits of reduced costs from vehicle ownership and maintenance have been emphasised as well.\(^5\) However, much less is known about a) the magnitude of these effects for individual users, and b) the social or equitable distribution of such benefits. As one recent article has suggested, it is likely that early developments of CAV technology in passenger transport will be “catering to the needs of middle-class, often young(ish) urban professionals and [will be] closely entangled with gentrification processes”\(^6\).

6. The claim that is sometimes made about the elderly and disabled significantly benefiting from the deployment of CAV technology in passenger transport\(^7\) is particularly problematic. Such benefits will only accrue with level-5 automation (which, according to some commentators, will only become widely available after 2030). Further, in light of their cost premium\(^8\), it is very unclear whether CAVs will be affordable and acceptable to the elderly and disabled. There are, in short, serious questions to be asked about the social equity of CAV user benefits.

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7. In addition, the question about user benefits should not distract attention from the indirect effects on non-users and the wider societal benefits and disadvantages of CAV technology adoption in transport. Key to discussing indirect and societal effects is an understanding of how CAV technologies will become part of the wider transport system. This is an area of deep uncertainty at the moment, and radically different scenarios seem plausible. If, for instance, CAV technology is used to turn car use into a service that fulfils specific functions in a truly multi-modal transport system with combinations of rail, bus and cycling at its backbone, then the social and environmental effects for users, non-users and society more generally may be (very) positive. If, however, CAV technologies become deployed to re-entrench the dominance of privately owned cars and thereby reduce the attractiveness of public and active transport, then indirect and societal effects may be much more ambiguous and addressing such challenges as reducing social inequality and increasing physical activity will become much more difficult. If CAV technologies are powered by fossil fuels, significantly reducing greenhouse gas emissions and pollution from transport will also become more difficult. These points reinforce Thomopoulos and Givoni’s conclusion that CAVs will only become a blessing “if technological development will be accompanied by a social change [whereby] public and sharing will be seen as superior to private and individual transport”.

8. The importance of the above points about health and equity becomes clearer once attention is focused on the link between transport and physical activity. Motorised vehicles (both automated and non-automated) require less physical activity than walking or cycling, or even than public transport, which usually involve a walking component. The Global Burden of Disease study projects that physical inactivity is responsible for 3.3% of worldwide deaths and 19 million disability adjusted life years annually, and that those that rely on motorised transport have higher rates of diabetes, cardiovascular disease, and obesity than those that walk or take public transport. Far better transport options – from both an emissions standpoint, and an energy efficiency standpoint – are to rely on a mix of walking, cycling, and public buses and trains, as Figure 1 indicates. From emissions, energy efficiency, and health standpoints, a mix of active and public modes is optimal. The potential for reduced physical activity as automated vehicles are adopted is a concern, which is why the development of comprehensive visions about how CAV technology is embedded in the wider transport system is such a pressing concern.

Figure 1: Energy and Carbon Intensity of Transportation Modes\textsuperscript{10}

9. Indirect impacts of CAV adoption are also likely in freight transport as three common concerns in the freight industry actors – the HGV/ LGV driver shortage, fuel duty and road infrastructure\textsuperscript{11} – are likely to be impacted by the introduction of automated vehicles. The driver shortage may be exacerbated by the expectation of automated vehicles reducing the need for professional drivers in the future. This needs to be managed to overcome short-term driver shortages, and to ensure skills are being developed. The impact that automated vehicles, which are widely assumed to be electric vehicles (where possible – or alternative other forms of low-carbon fuels), will have on fuel duty is not yet clear. There are, however, opportunities to increase driving efficiencies and thereby reduce fuel consumption and costs, as well as emissions (CO\textsubscript{2}, NOX and PM), particularly in the urban environment. Automated vehicles could benefit the freight industry by overcoming drivers’ hours rules in the UK. As with passenger vehicles, non-automated modes also require attention; the impact that automated vehicles will have on rail and coastal shipping requires consideration. A systematic evaluation of the potential impacts of automated vehicles on the freight industry is needed.

How much is known about the potential impact of deploying autonomous vehicles in different sectors?

10. From a freight transport perspective, different types of automated vehicles (e.g., small delivery robots, drones, automated vans) will offer very different services. These are likely to intersect with industries particularly healthcare and motor vehicle parts, but


\textsuperscript{11} Road Haulage Association (2016). Top Industry Issues.
increasingly general retail, which are dependent on high-speed deliveries, often through congested roads.

How much is known about public attitudes to autonomous vehicles?

11. A number of studies on public perceptions of, and attitudes towards, autonomous vehicles have recently been conducted in a range of countries.\(^{12}\) The general picture that emerges from these is that public opinion is reasonably divided about autonomous cars. A French study by Payre et al. claims that about 2/3 of the sampled individuals has positive attitudes towards full automation but little information on the sample and its representativeness of French drivers is offered. An international study by Kyriakidis et al. based on 5000 responses from 109 countries found, however, that manual driving tended to be preferred over fully autonomous driving. More than two thirds (69\%) of participants in the latter study also believed that fully automated driving will reach a 50\% market share between now and 2050. Substantial numbers of participants were concerned about software hacking/misuse, legal issues and safety. Other work using data from Austin, Texas by Bansal et al. and from Germany by Hohenberger et al. suggests gender differences in acceptability and interest, with women more likely to experience negative emotions (anxiety) towards autonomous cars. In addition, there may be cohort effects with younger individuals more positive about CAVs than older ones. It is also important to be specific about what type of autonomous vehicle is considered: Krueger et al. found that survey participants considered shared CAVs and individually owned CAVs two different mobility options.

12. To the best or our knowledge, there is no research published in peer-reviewed journals on CAV acceptability among the general public in the UK. Given differences in transport cultures, user practices and the physical lay-out of transport and land use patterns between the UK and countries where peer-reviewed research on user acceptability has been conducted.

13. It is also important to appreciate that not all individuals will want – or be able – to drive. For instance, a recent study on attitudes towards ride-sharing in Denmark by Nielsen and colleagues\(^{13}\) identified different market segments of travellers and noted that many of them, for instance steadfast bikers, or those that strongly prefer mass transit, would continue to resist private cars. Others seem to make travel choices based on “non-decisions,” rather than active deliberation about travel options.

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14. In short, on the basis of currently available evidence, it would seem that public opinion on autonomous driving is reasonably divided. Caveats must be made, however: at present familiarity with CAV technology is limited, and very few people will have direct first-hand experience of driving or interacting with autonomous vehicles. Questions can therefore be raised about the extent to which results from recent studies can be extrapolated into the future. It is to be expected that public attitudes will shift and co-evolve with further development and diffusion of CAV technology, and these shifts can go in many different directions: greater support is a possibility, but so is the emergence of significant resistance and contestation. It is impossible to predict what will happen, and much will depend on the outcomes of demonstration projects and reporting in the media. Accidents with autonomous cars may have a significant impact on public attitudes, but as—fortunately—there seems to have been only one fatal accident, Joshua Brown\textsuperscript{14}, so far, it is too early to tell how public opinion will be affected.

15. To the best of our knowledge, there has been no work to date examining the perceptions of the freight industry, nor public transport providers. Such research is necessary in order to better understand how the technology may be adopted by different user groups. It has been suggested that there is a ‘strong undercurrent of denial’ with US truck drivers believing that the technology is both undeveloped and not necessary\textsuperscript{15} but more and more systematic engagement with multi-modal freight industry representatives is in order.

Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?

16. The four demonstration projects in Bristol, Greenwich, Milton Keynes and Coventry are welcome and important. They involve a suitably wide range of partners and stakeholders. However, there is scope for experimentation on a wider scale:

- The conditions for transport and mobility differ widely across UK cities, towns and communities, and not all of these are currently covered. There is a need for testing in settings where cycling makes up a larger share of the modal split and for experimentation in more rural settings. There may be opportunities for CAVs to address access and public transport inefficiencies for rural towns and villages; further examination of this potential is required.
- There is a need for more testing and demonstration on motorways and other interurban roads, particularly also with a focus on freight transport. In many ways interurban transport is easier to automate because of the lower levels of complexity compared to urban mobility.
- There is a need for demonstration projects aimed at social inclusivity—e.g. by focusing specifically on the mobility needs of non-able-bodied and elderly people.
- There is also need for a more refined look at the distributional effects of CAVs on things like the vulnerable and social justice concerns.

What does the proposed Modern Transport Bill (MTB) need to deliver?

\textsuperscript{14} The Guardian (2016) Tesla driver dies in first fatal crash while using autopilot mode, 1 July 2016.
17. As argued at the beginning of this response, it is essential that the MTB places CAV technology in the context of a) the wider transport system and b) the grand challenges that transport in the UK is currently facing. The MTB needs to focus not only on economic considerations but also – and perhaps especially – on how UK transport policy can contribute to such aims as increasing life chances and opportunities to flourish for all UK residents, reducing social inequalities, increasing physical activity and everybody’s health and wellbeing, improving air quality and drastically cutting greenhouse gas emissions from transport. This means that a truly integral and integrative bill is needed that adopts a long-term outlook and does not look at CAV and smart mobility in isolation from other transport. This also means that more is needed than a focus on enabling the development of new technologies for road, rail, air and water-borne transport, the promotion of innovation, and the cutting of red tape.

Is the Government’s strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?

18. As already suggested, it is imperative that the Government’s strategy needs to place CAV technology into a broader context, one that involves more holistic analysis of interactions with other transport infrastructure as well as social and environmental issues including health and social justice. Attention needs to be directed to the (realistic) possibilities of unintended consequences of CAV technology integration in private vehicles on public transport, walking and cycling as well as the extent to which CAV technology diffusion may clash with existing policy objectives, from greenhouse gas emission reduction to increasing physical activity.

19. Further, the history of technological transitions in transport, including the rise of the fossil fuel powered car in the period 1890-1950, suggests that transformations are long-term processes. This means that government policy needs to consider multiple time scales: long range planning is just as much needed as policy that relates to the years until the next general election. The current strategy would benefit considerably from adopting a longer-term perspective. Doing so will not only place CAV technology into the context of the wider transport system and broader societal challenges; it will also ensure they contribute the most to UK society.

20. Adopting a long-term perspective will also draw greater attention to other issues where a pro-active approach by Government is desired. These relate to the wider processes of transition towards greater autonomy in (multi-modal) road transport, and include: the financing and provision of CAV infrastructure (e.g. sensors outside vehicles); the maintenance of such infrastructure, the standardisation of sensors, data and operation systems; integration of data, software and operation systems across different private operators with specific commercial interests; and the embedding of CAV technologies in a multi-modal transport system that offers seamless mobility for both persons and freight.

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