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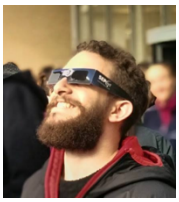

Paving the Way for Driverless Cars: A Policy Roadmap

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Driverless cars pose an unprecedented opportunity to transform the way we transport goods and people through cities and across countries, presenting benefits to our collective safety, environment and economy. They also pose new risks; as cars become more connected, they become more vulnerable to malicious attacks by thieves and terrorists. This essay argues that, ahead of the 2017 review of domestic regulations on autonomous vehicles (AV), the government should take active steps to position the UK at the forefront of the technology by providing a coherent policy framework, establishing itself as a world-leader in this rapidly approaching disruptive innovation.

On the road today

The U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) defines an autonomous vehicle as one that can operate 'without driver input to control the steering, acceleration, and braking'. Various automotive manufacturers (Jaguar-Land Rover, Audi, Volvo), as well as software companies (Google, Über), are heavily invested in the development of such technology. As a result, cars are becoming more autonomous feature by feature, with new Volvos, Audis and Chevrolet models exhibiting 'semi-autonomous' capabilities such as lane-assist or emergency braking. The most advanced vehicle currently available to consumers is the 2014 Tesla Model S, featuring five distinct AV capabilities: auto parking, auto steer, auto lane-change, side-collision avoidance, and 'summon' (which allows owners to park and retrieve their Teslas wirelessly). In response to these innovations, four UK cities have now been chosen to become 'test-beds' for AV technology in the near future. Starting in 2017, London, Coventry, Milton Keynes and Bristol will trial privately provided driverless 'pods' and buses, testing a 'code of practice' developed by the Department for Transport, in consultation with the UK Autodrive Consortium[1]. These schemes will allow the autonomous pods to transport members of the public along certain roads and pavements, aiming to both demonstrate the capabilities of AV, and gauge public perception of the technology.

On the road tomorrow

Experts estimate that the proliferation of autonomous vehicles on public roads will take place between 2020 and 2025 [2], subject to regulatory compliance. Tesla CEO Elon Musk has announced that a fully autonomous Tesla will be on the roads by 2018, but that regulators will most likely take one to three years to allow full autonomy on roads [3]. The US secretary of Transportation has stated that driverless cars will be prolific on American roads by 2025 [4], with HIS Automotive stating that driverless cars will account for 9% of global auto sales by 2035 [5].

Many key opinion leaders agree that the current model of vehicle ownership will evolve as AV becomes more commonplace. The CEO of Über (a $50bn dollar, Google-backed company) has claimed that users can expect a driverless fleet by 2030 and that car ownership may become obsolete as driverless ride-sharing becomes ubiquitous [6]. In his book, 'The Mobility Revolution', Neckermann argues that car ownership is already becoming 'more pointless' with urbanisation, resource reprioritisation, and the increasing availability of delivery services

[7]. Binding significant capital in assets that remain idle for much of the day will make increasingly little sense, with consumers choosing to purchase not vehicles, but mobility. Consumer reports suggest that attitudes are accommodating to such a shift: Deloitte's 2014 report on global transport preferences indicates that young people are increasingly willing to forego car ownership, especially in heavily urbanised areas [8]. Neckermann explains that the evolution of ownership structures and the emergence of AV ride-sharing, will act not as a replacement for public transport, but instead as a 'feeder' system, complimenting large-scale electrified transit systems by providing 'last mile' transportation for commuters in cities. With proper planning, autonomous vehicles could function as a complimentary infrastructure to public transport systems already in place.

Winners and Losers

The environment stands to benefit substantially from the adoption of autonomous vehicles. The Pew Centre on Global Climate Change claims that transportation emissions amount to 30% of those contributing to global warming, with cars and trucks alone amounting to 20% overall [9]. The electrification of cars is one big step towards reducing this figure: the UK government is currently aiming for 100% electrification of road vehicles by 2050, with over £1bn committed to achieving this goal before 2020 [10]. This would allow power production for automotive transport to shift from individual cars (relatively inefficient and predominantly fossil-fuel powered) to renewable sources, such as solar, wind, and hydroelectric, reducing both air and noise pollution in densely populated areas. Cities worldwide are producing more of their energy from renewable sources, with some (Copenhagen, Munich, and others) aiming for 100% renewable power by 2025 [11]. Electrification and AV technology are excellent compliments for one another, and the roll-out of AV may well result in a faster diffusion of electric vehicle technology. Autonomous vehicles will be able to drive themselves to charge-points for automatic recharging at no inconvenience to the driver, helping to overcome 'range anxiety', the most significant hurdle for electric cars right now [12]. AV technology will also allow cars to trace paths along roads with in-built wireless charging technology, allowing them to charge on the move. This not only increases the car's range, but decreases its required battery size, making it lighter and less damaging to roads than conventional cars. Fuel-inefficient aspects of conventional driving (such as regular stopping and starting) will become less common as communication networks allow cars to understand and predict each other's movements, perhaps even allowing cars to pass through busy intersections without slowing down [13]. As AV 'ride-sharing' becomes more popular, fewer cars will be needed on the road to achieve the same number of journeys, helping to reduce emissions even further.

Road safety will be transformed as software replaces human drivers. Each year there are a reported 1.2 million deaths from road accidents, with an additional 50 million people injured or disabled. Road traffic accidents currently rank as the leading cause of death amongst people aged 15-29 [14], and in 2013 there were over 1,700 deaths in the UK alone, with 132 of these occurring in London [15]. In contrast, Google's driverless cars have now clocked up over 1.7 million cumulative miles on American roads (they are currently averaging over 10,000 miles per week) and are yet to cause a single accident [16].

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Some industry experts are predicting that the reduction in accidents caused by a mass AV roll-out would be unprecedented. Ryan Hagemann, Robotics fellow at TechFreedom, has claimed that in an all-autonomous world, a reduction in deaths of 99.99% is not

unreasonable [17]. A study by the Eno Center for Transportation showed that over 90% of traffic deaths worldwide are caused by human error, and of these, over 40% were influenced in part by alcohol or fatigue. If just 10% of cars on US roads were self-driving, they claim 1,100 lives would be saved each year, rising to 21,700 with 90% of all cars driverless [18].

The increased connectivity of autonomous vehicles is what allows them to gather the information they need to function, but also provides additional avenues by which they could be hacked, controlled or maliciously manipulated by thieves and terrorists.

Driverless cars present the UK with a valuable economic opportunity. The potential market for autonomous vehicles will reach $42bn by 2025, with 58% of consumers globally indicating their willingness to purchase driverless cars [19]. AV technology presents opportunities for auto-manufacturers, as well as efficiency gains more widely. The average employee spends the equivalent of more than a working week stuck in traffic per annum [20], with an estimated €100bn lost due to employee time wasted in traffic jams in the EU each year [7]. These figures could be reduced significantly, with AV vehicle-to-vehicle (V2V) communication networks and fleet logistical planning predicted to reduce congestion. Driverless technology also frees up time for would-be drivers to enjoy as they wish – be it for leisure or for work. Blind, elderly, and disabled people who are currently unable to drive stand to have their lifestyles transformed by AV, allowing them to travel with a greater level of autonomy and safety. To this end, AV proliferation offers a vision for a fairer and more equitable society, not just a wealthier one.

The picture isn't all roses: some industries stand to lose out in the driverless revolution. Currently, around 300,000 people in the UK are employed in some capacity as professional drivers (truckers, Über drivers, taxi drivers, bus drivers) – jobs that will be jeopardised when AV technology becomes price competitive with ordinary cars and drivers' wages. Currently, various unions are battling to protect their workers from encroaching technologies such as Über, with little success [21]. Various automotive 'ancillary' industries will experience significant disruption from AV technology. The automotive insurance industry (with a global market size of $198bn) will be forced to adapt; as accidents become rarer, and as traditional ownership patterns evolve, premiums will fall and new product innovations will be required. The automotive finance market ($98bn globally), parking industries ($100bn) and automotive 'aftercare' market ($300bn) stand to suffer losses due to the rise of safe, fleet-owned, self-parking vehicles [22]. Traditional car-parks in cities, for example, are expected to serve a decreasing user base as fleet-owned self-driving cars drop off their occupants and immediately move on to pick up their next customers. The increased structural unemployment that will result from autonomy in vehicles, as well as various other industries, is an aspect of technological progression that should be taken seriously by government.

Cyber-security and terrorism risks

The increased connectivity of autonomous vehicles is what allows them to gather the information they need to function, but also provides additional avenues by which they could be hacked, controlled or maliciously manipulated by thieves and terrorists. Already, hackers have demonstrated the ability to significantly disrupt or immobilise self-driving cars using laser pointers and other off-the-shelf technologies [23]. In mid-2015, Fiat Chrysler were forced to recall over 1.4 million vehicles on safety grounds, after researchers were able to wirelessly hack a Jeep Cherokee's internet-connected entertainment system from 10 miles and seize partial control of the car [24]. White Hats (or 'ethical hackers') from Lookout and CloudFlare were also able to hack into the Tesla Model S (touted as the most secure car on the road), turning off its

dashboard and disabling various basic functions during driving [25]. The FBI recently compiled a report on these risks, in which it was suggested that AV could be used as 'lethal weapons', as 'accomplices in criminal activity' by aiding in getaway car-chase situations, or to cause 'chaos' in cities by bringing roads to a standstill [26].

Building a policy roadmap

This essay takes a positive, 'techno-optimistic' view of autonomous vehicles and the impacts they can have on society; it is hoped that, given the evidence presented, policy makers will share in this view. Policies suggested here actively encourage the societal interest in, development of, and proliferation of AV in an attempt to establish the UK as a world hub for the technology. Suggested policies for the government to consider include:

I. *Employ to a greater extent the 'Triple Helix' model [27] by creating and facilitating relationships between the UK government, the UK's world-renowned automotive manufacturing and research industries, and university research institutions, to foster innovation in AV technology. This could involve providing funding and resources for university research labs and businesses to collaborate on, develop and test AV technologies.*

II. *Coordinate dialogue between government, local councils, property developers and infrastructure developers to best understand how to incorporate AV technology 'from the ground up'. This could involve building wireless charging ports into residential and commercial developments, and reducing the number of parking spaces in future residential blocks in anticipation of evolving ownership models.*

III. *Increase funding of 'test-bed' schemes currently running in four UK cities, and expand these schemes to include more cities and to serve more people. Continue to publicise and explain their relevance to local residents and visitors.*

IV. *Request evidence for, and feedback on, possible legal obligations regarding AV cyber-security. Work in collaboration with automotive manufacturers, software providers and think-tanks to ensure that these obligations are easily understood, are achievable in the short term, and are sufficient to protect road-user safety without hindering innovation.*

Conclusion

There are a number of positive consequences of the emergence of self-driving cars, as well as potential dangers that should not be ignored. These four policy recommendations focus on providing funding for UK scientists and engineers to develop cutting-edge technology, fostering infrastructure developments that can facilitate AV use, encouraging positive perception amongst the public, and ensuring the safety of AV users. Adopting policies that encourage the development and adoption of safe autonomous vehicles has the potential to establish the UK as a world-leader in a technology that is set to revolutionise transport in the 21st century. Let's embrace it with open arms.

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About the Author

Ed is studying for an MPhil in Technology Policy at the Cambridge University Judge Business School, specialising in innovation, disruptive technologies and entrepreneurship. He recently graduated as a Master of Engineering, Economics and Management from Oxford University. Ed is also a contributing writer for the Cambridge Wilberforce Society, focusing on autonomous vehicles and Artificial Intelligence. Previously, Ed has worked in the engineering world, start-ups, private equity, and has lectured in China.

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