Professor Paul Newman, University of Oxford – Written evidence (AUV0041)

Impacts and benefits

1. What are the potential applications for autonomous vehicles?

It is difficult to overstate the impact of vehicles that are able to move around and answer the key questions for autonomy (‘Where am I?’, ‘What’s around me?’, ‘What should I do next?’) in ways that benefit us. However, a common mistake is to focus too narrowly on autonomous cars. They are important, and there will be a point in the future when they become generally available, but they are the ‘stellar application’ of autonomous vehicles and as such have special status. We should do ourselves the favour of thinking about ‘all the things that move’ and therefore have our mind’s eye on every port, warehouse, hospital, post office, road and train station. Autonomous vehicles have a role to play in any setting where human beings are moving people or objects around.

It is also essential to consider all the applications of this technology, not just the applications of fully autonomous vehicles. Even before we achieve full autonomy, there are a very large number of advances that will become possible as a result of the progress we are making towards it. This point is subtle and often missed. In the near future we will see cars with ‘Guardian Angel’ autonomy: they will have the ability to take control for short periods of time in critical situations, such as when the vehicle is about to crash. Aspects of this technology are already in place; ABS systems, for example, allow the vehicle to moderate the negative effect of a driver braking too hard. Advances in autonomous vehicle technology have already made, and will continue to make, a very significant impact long before we achieve ‘driverless cars’.

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

The question has to be answered with great care, because it depends what timescale we’re thinking about. It is also important to approach it in terms of the sectors we’re focusing on. It is easy to talk about the advantages of a world where autonomous vehicles are fully deployed – that utopian point sometime in the future where people will be able buy a car with no steering wheel which will safely drive them to any place at any time in any weather. The benefits of this are obvious and positive; for instance it will enable someone who is blind to visit family who live at the other end of the country, or enable someone to work while their car drives them to a meeting.

However, there is a stage before that. At an intermediate level of autonomy, we have not yet fully grasped what difference Mobility-as-a-Service could make in some of our bigger cities, where private ownership isn’t so attractive. There is a lazy argument that this will revolutionise all transport so that no one owns their own car any more, but this is very unlikely: private and public are going to be blended for quite some time. In the meantime, Mobility-as-a-Service has the advantage of offering some fairly fine-grained control on how vehicles flow and interact in our big cities.
Increased safety is a significant benefit, because machines don’t get distracted in the way that people do. Between 70% and 90% of car accidents are caused by human behaviour and error. The McKinsey Report into Disruptive Technologies 2013 estimates that by 2025, if autonomous vehicles prevent only 20% of driver-caused deaths from car accidents, 150,000 lives a year will be saved. Because autonomous vehicles can drive more efficiently, there is a potentially huge impact on CO₂ emissions, which could be reduced by as much as 300 million tons per year (equivalent to 50% of CO₂ emissions from current commercial aviation).

Advances in the use of autonomous technologies in warehousing have already changed the face of shopping and will continue to do so. We now have the ability to browse the entire world for thousands of products, made possible by new warehousing technologies. There is an enormous opportunity for the use of autonomous vehicles in agriculture – not just harvesting crops mechanically, but doing farming in a completely different way. For example, there is the potential for vehicles to ‘see’ and apply herbicide to just the growing buds of only the weeds, not the entire crop. There are also major advantages in sectors like security (such as the deployment of autonomous vehicles to defuse IEDs).

One risk is that developments may be pushed through artificially fast, so that people become ‘spooked’ by the technology. People will be concerned about loss of jobs. Of course there will be changes of employment because of these vehicles, but this is not necessarily a disadvantage and certainly not a reason not to continue to develop them. Technology has always led to employment changes, and it is hard to see how the deployment of autonomous vehicles will become some sort of tipping point for job losses.

Because we will have more vehicles that are able to operate with more autonomy, there will be new kinds of jobs, but it will be a very long time before robotics and automation replaces the need for a human. For example, a forklift driver over the next 30 years will encounter more autonomous forklifts, but that may just mean that each operator runs six forklifts instead of one. There will still be many scenarios in situations such as warehousing where human ingenuity, intuition and perception can solve a problem infinitely more quickly than a machine. The fact that the forklift is capable of driving itself to the other end of the warehouse enables the forklift operator to get on with tasks that really do require human-level skills. There are only a few corner cases in the field of autonomous vehicles where it is possible to perceive that there will be no human involvement at all, so it is more realistic to talk about changing jobs rather than losing them.

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

Rarely do we find a sector that isn’t both terrified and desperately excited. A good analogy for the discussions we are having now about robotics and autonomous systems is the conversations we had 30 years ago about computing – for example, spreadsheets replacing card index boxes. We use different nouns, but it’s effectively the same topic.

My view is that there are some sectors such as mining where people have not yet fully grasped the potential of autonomous vehicles, and that in other areas such as stevedoring
there could be issues around the impact on the workforce. Heavily unionised sectors might be difficult places to implement technology like this, should we choose too, but personally I don’t believe that the technology should be forced on people. It’s a societal decision: I fully support the right of society to make those choices. I also believe strongly in giving society the opportunity to change the way it does things, rather than being forced – and ultimately the economy is what brings about this change.

4. How much is known about public attitudes to autonomous vehicles?

No comment for this question.

5. What is the scale of the market opportunity for autonomous vehicles?

It is huge, and hard to exaggerate. In the field of autonomous cars and trucks alone, the McKinsey Report 2013 estimates that the benefits provided by improved safety, time savings, productivity increases, and lower fuel consumption and emissions could have a total global economic impact of $200 billion to $1.9 trillion per year by 2025. This does not include autonomous vehicles in sectors such as warehousing or farming. In the UK, the Robotics and Autonomous Systems (RAS) Strategy document (June 2014) estimates that, over the next 20 years, the economic benefit in terms of national costs avoided thanks to the use of RAS in transportation will be in the order of £1 trillion. The market size of the Logistics and Transport Sector expected to be affected in the UK is £112 billion. This is not so surprising when you consider that we are talking about all the things that move.

Creating an enabling environment

Research and development

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

In my view, no. At the moment we are trying to make the leap from closing off a few pavements in Milton Keynes so that we can trial autonomous vehicles, to full-scale deployment in a city like London. The gap between these two scenarios is enormous; you can talk about ‘the urban laboratory’ and cite any city in the world, but you need to be able to control demonstration facilities more than that.

In between we need a facility that is essentially a real community where people live and others come to work, which has roads in it, and the need for transport, logistics and service robotics, but over which you can also exercise some degree of control. This would provide a space where very different kinds of trials could be run: from someone new to the field of autonomous vehicles who wants to ‘have a practice’, through to established groups who have a more ambitious plan to identify a service gap in the community that they might be able to fill.

Somewhere like Culham in Oxfordshire would provide the perfect opportunity to do this.
It is a campus environment that is also a community, a place that has transport links to train stations and all sorts of other ‘real world’ detail, a place where insurance can work but where you can also control aspects of safety. There is an opportunity here for us to do something that the US isn’t doing. They have the MCity Test Facility in Michigan, which is a realistic environment but not a ‘real place’ in the sense that Culham is. Nobody without an interest in driverless cars goes to work in MCity. We need to be operating demonstration facilities in a place where some people are enthusiastic but others are sceptical, so that we can enable them to see the potential and the benefits.

One thing we absolutely must not do is just build open test tracks, because that is exactly not what a city is.

7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?

I believe the Government is doing a very good job here. CCAV is excellent; it is staffed with extremely competent people who understand the issues and who are there to help in a good hands-on way. The Research Funding Councils have also done a good job in getting behind some of those mobility programmes.

The most important signal to give is this: autonomous vehicles are not a ‘problem’ you can throw a lot of money at in order to solve quickly. You can’t just fund it and see if it catches alight; you have to keep on starting fires so that the right people will come to the UK, start businesses and then stay in the UK because they see that there is opportunity here. You don’t need to spend billions doing this, but what you do need to have is a continual financial backing. This speaks to a strategy for this technology in the UK. If we invest in this area, continually, over the next decade, we could have the autonomous vehicle equivalent of Silicon Valley here in the UK.

There is a need for a ‘sticky’ science policy in this area. The Government has done an excellent good job in starting CCAV and the Intelligent Mobility Fund, and what needs to happen now is for us to stick at it. We should not be distracted by Google or Apple announcing that they are getting into autonomous vehicle technology. That would be akin to telling Dell not to start a computer company because IBM exists. We have the same brains trust here as the US does, and what we need to do is build a culture of sticking at robotics and autonomous systems. That is something that government singularly can do.

Government should not become preoccupied with legislation; so far it has done a very good job of using a light touch. It should also stay well away from trying to do industry standards, which would be too restrictive and time-wasting. While people are still figuring out how to do things, standards would only inhibit the rapid pace of change. Standards will happen eventually, but it’s not the place to spend money at the moment.

8. How effective are Innovate UK and the CCAV in this area?

Across the board, I think that all the agencies involved in this area want to get it right. Innovate UK deserve a lot of credit for the efforts they have made, especially in view of how
long it has taken to get some of the initiatives going.

However, I think there are difficulties at Innovate UK about the pace at which this is happening. Their desire to do the right thing isn’t in question, but the detail of how things are administered is sometimes orthogonal to what is needed. Innovate UK needs to be totally committed to autonomous vehicles, again with a ‘sticky’ policy to make a sovereign capability in autonomy in the UK. They need to understand that long-term, recurrent funding is a very important role for them to have. I believe that Innovate UK’s enthusiasm and excitement about autonomous vehicles will enable them to fix this.

9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?

No comment for this question.

Real world operation

10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?

The key word here is ‘require’. It is possible that in future there will be business or wealth generation opportunities that may induce changes to infrastructure. But these changes should not be seen as a *precursor* of autonomy; that would be disastrous, and the wrong role for Government. There are vehicles already in existence, such as Google cars, which prove that dedicated infrastructure is not needed.

There are situations in which infrastructure can usefully be considered as part of the planning process. So for example in China, when building roads for new cities, they are now putting in the equivalent of cycle lanes for Mobility-as-a-Service. If you were building a new Olympic Park, you could imagine putting areas aside for the autonomous mobility systems which will move people around the park. But there is absolutely no requirement to dig trenches alongside all existing roads and lay wires and sensors to control autonomous vehicles. For a long time to come, we will be able to do this job very effectively using the 4G phone network and the internet – and we have already built those.

Some aspects of infrastructure will be undoubtedly be useful, but that is not the same as saying that they are required, and their development will be regulated by the market and by factors such as insurance, not by Government.

11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?

The key events that need to happen are social and economic. In terms of technical advances, development is relatively smooth, without noticeable revolutions. As with computing, the technology is continuously getting a little bit better all the time. But with regards to the social acceptance of autonomous vehicles, there are discrete steps that we will need to go through.
On the technical side, it is important not to take the attitude that deployment has to wait until we have a ‘finished product’. Of course there is still a lot of technical development that has yet to happen before we have a car with no steering wheel, but we can start to deploy the technology that we have now. Asking ‘when will I have a driverless car?’ is a bit like asking ‘When will I have a computer?’ It is not something that will ever be ‘finished’ in that sense.

In terms of management of risk, I think commercial factors will manage the process. Insurance is an important way to deal with some of these risks – insurance is all about risk, after all – and the conventional model is likely to be changed completely by the move to autonomous vehicles. For example, there might be the potential for autonomous cars to bid automatically for insurance cover for individual components of a journey (such as risk at a particular junction). The insurers are then directly assessing the safety of the vehicles at any point. I don’t think it will be possible to completely ‘prove’ safety before vehicles are deployed; I think it is something that will be assessed and measured during deployment using tools such as insurance.

Social milestones, however, are the critical ones. Initially there was elation and anticipation about autonomous vehicles, and now there is more uncertainty; we need to work towards public acceptance and trust. This is something that Government can definitely assist with; as part of its leadership role in society, it needs to help deliver the messages about this technology and what it can do.

One very important milestone is how we manage the first ‘big crash’ involving autonomous vehicles, because there will be one. In advance of that event we need a sensible, pragmatic conversation that there are inevitably going to be accidents. As a society, every time we build something new, unexpected things happen. That is not to say that we’re not being unbelievably diligent engineers, but we do need a narrative that says there will be new, but on the whole fewer, accidents. If for some reason that turns out not to be true, the economy will not tolerate it, and there will be no driverless cars.

A complicating factor is that the focus of much of the excitement – the car – is an article that has a ridiculous amount of influence over how we define ourselves. We also have a completely unrealistic expectation of the provision of service in these vehicles; we are totally intolerant of them going wrong. For this reason it is even more important that we understand driverless cars in the wider context of all the machines that might move for us. It is why warehouses and ports may be the first places where we see the deployment of this technology, because they are already considered a kind of ‘at risk’ situation, and also because people don’t have their personal esteem attached to forklifts in the way that they do to cars.

12. Does the Government have an effective approach on data and cybersecurity in this sector?

No comment for this question.

13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?
No. It would be best to leave it as it is, without regulation, and let developments happen for a while.

14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?

There is an attitude that autonomous vehicles are ‘thinking machines’ capable of making moral choices, and this is not remotely true. Many situations arise in which physics dictates that someone or something is going to get hit by a vehicle. This is not the fault of the machine.

However, if we are building machines that are capable of making split-second assessments of these situations, then we need to unpick what is actually going on and discharge some of the tension around these vehicles being ethical agents. We need a discussion about how we want those machines to act. Do we want the outcome to be random? If the choice is between hitting an adult and hitting a toddler, do we want the vehicle to save the child? Do we sacrifice two passengers in the car to protect five pedestrians? This may sound calculating, but we make exactly these sort of calculations already for insurance purposes. These decisions will be made by humans; the car is then, in fact, only making an ‘ethical’ decision that has been programmed into it by people. It could be very beneficial; we could have situations in which better decisions are made, because machines (unlike humans) will not panic.

An advantage of this capability is that autonomous vehicles will be able to replay the accident so that we can assess whether the machine did what the software told it to do, and whether the outcome was reasonable. This will provide auditable evidence that we have not previously been able to access.

This is not really Government’s responsibility, but there needs to be a changing of the narrative around these driverless cars to address the question of who gets the blame when the car malfunctions in some way. It is essentially no different from using a tool that proves defective; if it fails once that’s bad luck, but if there are multiple failures – for example all the tyres in all autonomous cars start blowing out – then it’s a quality control issue and needs to be treated as such.

There may be social and economic issues that need to be addressed here, too. A recent paper in Science, ‘The social dilemma of autonomous vehicles’, found that ‘even though participants approve of autonomous vehicles that might sacrifice passengers to save others, respondents would prefer not to ride in such vehicles’. This poses a conundrum for companies who want to sell cars.

**Wider governance**

15. What does the proposed Modern Transport Bill need to deliver?

No comment for this question.
16. How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?

An honest answer would be ‘terrible’. This does not just apply to autonomous vehicles; it applies to the whole field of information engineering. In the UK we are not even close to imagining what we need to do to teach people to code properly. For 20 years we have confused ‘computing’ with ‘using the font selection dialogue box’. Of course people need to be able to use computers, but they need to understand what computing is as well. It’s like teaching writing without reading – half of the skillset is missing, and we wouldn’t think that was acceptable in any other subject.

I cannot overstate the importance of this: we need about 10,000 more engineers a year. We need to plough money into universities to teach information engineering, data engineering and software. Our future economy is not going to be about bending pieces of metal or shaping plastic; it’s going to be about making weightless software. The scaling you can reach through software engineering is huge. The example I would use here is Windows: a small number of people wrote the original operating system, but everybody in the world uses it. In terms of information engineering, we could be the nation that drives the revolution if we get the education aspect right.

Teachers at all stages of education need to be skilled up to think that software and computing, rather than the use of computers, is vital. I would like to see coding included as a core skill for SATS. Government singularly can effect this kind of change and singularly has the responsibility for this.

17. 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?

No, and this is understandable. The work on autonomous vehicles started with a kernel in CCAV, but what we need to do now is to grow the CCAV model to extend across all of Government to encompass BEIS, Transport, Defra, the MoD, DEC and the Home Office. All these Departments will be encountering ethical, efficiency, technological and social problems that relate to robotics. Imagine how many billions could have been saved 35 years ago in relation to computing if there had been a group that cut across all Departments to advise on how to navigate the changes, instead of every department having its own response. In retrospect, we would probably have played it differently. There is a similar opportunity now to get on the front foot with autonomous vehicles.

18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?

No comment for this question.

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