



Select Committee on Science and Technology

Corrected oral evidence: Autonomous Vehicles

Tuesday 8 November 2016

11.50 am

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Members present: Earl of Selborne (The Chairman); Lord Borwick; Lord Cameron of Dillington; Lord Fox; Lord Hennessy of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Lord Maxton; Baroness Morgan of Huyton; Baroness Neville-Jones; Lord Oxburgh; Viscount Ridley; Lord Vallance of Tummel; and Baroness Young of Old Scone.

Evidence Session No. 4

Heard in Public

Questions 31 - 39

Witnesses

[I](#): Professor Nick Reed, Academy Director at TRL, on behalf of GATEway (Greenwich Automated Transport Environment); John McCarthy, Technical Director at Atkins' Intelligent Mobility, on behalf of the Bristol driverless cars project; and Brian Matthews, Head of Transport Innovation, Milton Keynes Council.

USE OF THE TRANSCRIPT

1. This is a corrected transcript of evidence taken in public and webcast on www.parliamentlive.tv.

Examination of witnesses

Professor Nick Reed, John McCarthy and Brian Matthews.

Q31 The Chairman: Could I invite the Committee to reconvene and welcome our three witnesses in this session, Professor Nick Reed, John McCarthy and Brian Matthews? Perhaps as we are being broadcast it is necessary for the record for you to introduce yourselves, and if you would like to make an opening statement, please feel free to do so. Perhaps we could start with Professor Nick Reed.

Professor Nick Reed: Thank you, and thank you for the opportunity to speak to the Committee today. My name is Nick Reed, I am the director of the Academy at TRL, the UK's Transport Research Laboratory. I am responsible for co-ordinating research and innovation at the lab. I lead on vehicle automation and I am technical lead of the GATEway project that I am representing here today. TRL is the UK's Transport Research Laboratory, an independent, non-profit, distributing centre of excellence for research into all forms of surface transport and it has had self-driving cars for more than 50 years. The GATEway project is a collaborate R&D study, part-funded by Innovate UK and by the commercial partners involved, in which we will be testing a range of different automated vehicles in Greenwich. The Royal Borough of Greenwich is playing host to a number of connected and automated vehicle studies, so we have taken the opportunity to brand the Borough of Greenwich as the UK Smart Mobility Living Lab.

I am also pleased to declare that Lord Borwick is the chair of the cross-sector advisory group.

The Chairman: We have sussed that out.

Professor Nick Reed: I am sure you have. We have very helpful input from him.

John McCarthy: Good morning, all. Thank you for inviting me here. I am John McCarthy. I am technical director with Atkins consultancy. I am also technical director for the VENTURER project based in Bristol and south Gloucestershire. Atkins is a global engineering consultancy with roughly 20,000 employees. The VENTURER project that we are leading looks to create an independent test site on the Bristol and south Gloucestershire roads for the deployment, testing and validating of autonomous vehicles on real urban roads.

Brian Matthews: Good morning. My name is Brian Matthews. I am head of transport innovation at Milton Keynes Council. Milton Keynes is a unitary authority based in the south Midlands with a population of 260,000. My role in this topic area is to lead for the council the UK Autodrive programme, specifically looking at the research elements of the programme. Over the next year the city will be hosting demonstrations of saloon cars driving autonomously and the deployment of 40 individual pods as a public transport system.

Q32 The Chairman: Thank you very much. I am going to open the questioning with a rather general question. You will have noted in the earlier session—I apologise that

we have kept you waiting a while—that we ran out of time, so when I ask you to respond briefly, you will understand why. It would be helpful if you could give us in a nutshell a description of the trials you are carrying out, and tell us whether this is demonstrating a scientific and engineering process or testing elements of a system to be deployed, and to what extent you are looking at the social and behavioural issues which will arise from the introduction of this technology. Perhaps I could start again with Nick Reed.

Professor Nick Reed: There are three main trials in the GATEway project. The first is testing seven six-seater pods as an automated transport service on the Greenwich peninsula. The second trial is looking at how automated vehicles can be adapted to suit the needs of mobility-impaired, visually impaired and deaf transport users. The third trial is looking at the use of an automated delivery vehicle, so the extent to which it will be possible for deliveries in the city to be made by a quiet, automated, zero-emission vehicle. We are also looking at driver behaviour in the presence of automated vehicles, so using our driving simulator to see how drivers of manually driven vehicles change their behaviour when they are in the presence of automated vehicles. We also have a trial looking at remote vehicle operation, whether it is possible to take control of an automated vehicle from a control centre for vehicle management.

John McCarthy: VENTURER is looking to focus on the individuals, on understanding the behaviours and the relationship between people and autonomous vehicles, while not neglecting the need to understand the technology aspect of it. Through the consortium we have members from the insurance industry, academia, the private sector, and we are looking at understanding the relationships that these different elements can bring together to have a real and scale-able test site to address some of the issues raised in the earlier session. We have just completed trial one, which is looking at a handover mechanism, going from a situation where the vehicle is driving itself to where the driver has to take control. We are engaging through simulation and on road deployments in looking at creating scenarios where we can test offline, take that learning and deploy it in the real world. For trial two, which is taking place later next year, we are looking at the engagement of the autonomous vehicle with other road users, looking ahead at junctions and engaging with other drivers to understand user need and the technology requirements that underpin a smooth transition to autonomy.

Brian Matthews: The Autodrive project is a collaboration between 16 partners, made up of OEMs Jaguar, Land Rover, Ford, Tata Motors; SMEs, RDM, who make our pods; and the university sector, Cambridge and Oxford Universities, and locally the Open University, so it is a wide-ranging consortium. The three activities within the demonstration, as I mentioned earlier, are to demonstrate on the public roads of Milton Keynes and Coventry M1 saloon cars operating in live conditions, and those trials will take place towards the start of 2018. The second element is to deploy a fleet of 40 autonomous pods within the pavement areas of Milton Keynes, operating as a public transport system, a last-mile solution. One of the trials will be to integrate the connected cars, the M1 saloons, with the pod journeys to demonstrate they can connect. The third element is a cities research programme, as

we term it, which looks at some of the social factors around the public attitude towards autonomous vehicles and whether it changes within the life of the programme; the business case development of a last-mile public transport solution, specifically looking at the capacity benefits that may be unlocked by autonomous controls on the highway; and a future horizon scan of how the technology may develop in the short to medium term.

The Chairman: Coming back on that, one of the interesting issues which came out in the earlier session is the social issue—how people will react as they share their roads with assistive vehicles and eventually autonomous vehicles. There are clearly some interesting issues to explore on human behaviour: how people will react, whether we are talking about the person who is a driver, who is moving to a situation where they have less and less participation but remain in ultimate control, or a situation—and we are told it is some time ahead—where you eventually move to autonomous; also how third parties are likely to react. At some level will they play chicken and see whether the autonomous vehicle stops; or will there be concern in wider society at what appears to be a vehicle not obviously being controlled? Are these issues of human behaviour part of your project?

Brian Matthews: Certainly, yes. We are looking to explore current attitudes towards driverless technology, which is very new to the UK, and see what the acceptability is, without it really being demonstrated as it is in its infancy, and whether that changes through the life of the programme. We are comparing Milton Keynes, where there is a little bit more exposure to autonomy, to other areas, and we are also taking the survey out into international areas to test the areas, but the aspects you mentioned are all covered in the detailed survey. Certainly the chicken aspect we have noticed very readily: all the journalists want to jump in front of it and make sure it stops, and it does.

John McCarthy: For us, within the conversation around autonomy there are a huge number of questions. We are all struggling to understand what the answers might be in the near term. A lot of conversations are focused around technology—how technology can be deployed and how it can be validated. For us, putting the user at the centre of the conversation is the prime aspect of VENTURER, building the technology around that, building the integration with the road network, understanding the needs of the individual relating to the technology, the dependencies between the infrastructure, the vehicle and the human, and how they can all relate to each other within a new way of travelling.

We are of the mind that transport is changing to a mobility-type solution and how the individual can be part of that, which raises lots more questions around data protection, the security of the individual, the security of the system, the testing and the validating, which is driving us to create this independent test site to capture the behavioural aspects and the technology in a unified way.

Professor Nick Reed: The call under which these three projects were funded was explicit in saying it was not about the development of new technology but about testing those technologies and learning about how the public come to trust and accept these vehicles as part of an urban mobility environment. It gives us the

opportunity to engage directly with people, give them an experience of the use of automated vehicles, and then come to a conclusion about whether they would like to pay for transport using such vehicles. There have been a number of frankly unhelpful surveys which asked members of the public whether they think they would like a driverless car. It is very difficult to make a judgment on that when you have not experienced one. In our early demonstrations we have all seen that there is a lot of interest, excitement and ready acceptance of automated vehicles, so let us get out there, do the trials, and find out people's genuine opinions when they have used an automated vehicle.

The Chairman: Was Lord Maxton trying to catch my eye earlier?

Lord Maxton: Yes, it is a question on that subject: quite simply, you try and get people to drive an automatic car and they want gears—in America they do not but in this country they do. How do you react to that?

John McCarthy: I think the question really is: what do people want and why do they want it? The oft-quoted figure, and we heard it earlier, is that 90% of accidents are caused by human error, so if you are asking whether people want a safer way of going from A to B, people potentially will say yes. If you ask if they want an alternative technology which puts them in a new environment they might not be comfortable with, the answer might be no. We have to understand the full range of needs and user requirements to answer what people want rather than pushing a technology that is not what they are looking for.

Lord Maxton: I would not drive anything else but an automatic.

Lord Hennessy of Nympsfield: Are imaginations aflame in Greenwich, Milton Keynes and south Gloucestershire among the people who have experienced this? Can you peg it up a bit? There is no poetry in all this, is there? I have a vision—and I do not like the word “vision”; I think it should be left to mystics, but everybody has to have a vision these days—of being stuck in a driverless car on the A43, going to the immensely boring British driverless Grand Prix at Silverstone. Is there any poetry you can offer us or, for the people that experience it, does it take care of itself as a problem of imagination?

Professor Nick Reed: If we are giving people an exciting experience, we have done our jobs incorrectly.

Lord Hennessy of Nympsfield: But do you?

Professor Nick Reed: As John has said, if we want to offer people new ways of achieving mobility and regaining time, you may be able to access the time spent on the A43 in a traffic jam and use it productively or for relaxation. We want to improve safety. Human error is a contributory factor in the majority of collisions. We are directly addressing that through automation of the driving task. Safer, cleaner, more enjoyable journeys—it is not poetic but I think it is a good ambition to have.

Lord Hennessy of Nympsfield: Poetry in Bristol?

John McCarthy: We are very poetic in our thinking, landed in the reality of everyday concerns. We think about this as not replacing a new technology with an old type of solution. It is not a new way of going about our journeys; it is looking at unearthing new ways of engaging with how we live our lives, connectivity, autonomy, how you save time, create new services, and those services can be as fast and as wide as you might want them to be. Now we can pause TV—did we imagine something like that 10 years ago? That is one example of technology providing a benefit for people in ways that we cannot imagine right now. I think it is tremendously exciting, and the services that can be enabled from an autonomous future in the short term are for us to determine. Fundamentally, the non-poetic side of it is that we have to understand what people want and deliver a solution that is absolutely safe.

Brian Matthews: I liken it to the example where we all understand the risks or potential risks of using our credit card on the internet, but we still do it because the benefits are greater than the risks, because we like shopping. I see that as being the evolution of driverless cars in the UK: yes, we like driving, we like changing gear, but we might like using our phone a little bit more than doing that. I think that is how we see them developing, that the public will come to accept this technology because the benefits are greater than what they enjoy in the current offer.

As for how we see it in the city of Milton Keynes, for those who have been there, it tends to be dominated by the car; it is car-centric. We recognise it has a role to play but we also have ambitions for the city developing and growing and being more successful, and if we can start to remove the reliance on the car through a range of measures which includes autonomy and the last-mile solution, perhaps we can be more poetic with our city and develop a city example that our residents like better than the current model of cars everywhere, and parking everywhere.

- Q33 **Lord Mair:** You heard in the previous session a bit about trials and testbeds, and the three trials that you describe are obviously of great interest, but it is still early days; there is clearly a lot more needed. Could you say something about how much more we are going to have to do in the way of trials? What do you envisage as the next generation of trials, to get public confidence, testing technology in difficult conditions, potholes, driving in foggy, rainy conditions, all these kinds of things? What do you think are the next kinds of trials that will have to take place?

Professor Nick Reed: All of the three projects here are research projects for the urban environment, so we are geographically constrained. We need to think about what automation would look like in rural and inter-urban environments. None of us is seeking payment for the use of our automated vehicles. We need to understand what people would be willing to pay for these vehicles as a service. Event data recorders were talked about in the last session and what data those need to collect, at what level of accuracy, across what scope, how access is managed to that data to understand liability, and the interaction between manually driven, partially, highly and eventually fully automated vehicles, how the social interaction between a heterogeneous fleet would be achieved safely.

John McCarthy: From our side, from the VENTURER project and from an Atkins perspective as well, we are one year in. We have delivered one trial looking at the handover mechanism. That is one part of a huge jigsaw for autonomous vehicles. The second part is manoeuvring across the white line in certain circumstances, turning left and right at junctions. What we talk about is building up a series of increasingly complex scenarios. This is what we all look to achieve across all three projects, to build up that scenario where we have a list and an understanding of these different events.

We are only at the starting point of the testing environment. We need to understand the impact on infrastructure. We have yet to understand the full impact on the technology and the resilience that is put in place; looking at what the car industry is looking at, the individual within the vehicle itself, what it is that they look to engage with, whether it is or is not a steering wheel. These raise questions of how we create an environment that is realistic. Across the world we have lots of different test environments that are not necessarily on real urban roads, that do not complement the simulated world with the physical world, and that needs to be looked at.

I think there is a capability issue here. The UK as a whole can sell capability to the rest of the world. We have a number of test sites and we have a number of research projects under way. There are other research projects, and we should definitely bring that together in a unified offering to the rest of the world, because it gives us what we call a USP, a unique selling point.

The Chairman: Did you want to add anything, Mr Matthews?

Brian Matthews: Very quickly, I think we are all a year into our projects. Ours is a three-year project but results are emerging, and they have fed into CCAV and Government to give them sufficient confidence to set the bar higher for the next level of trials and demonstrations. As you are probably aware, there is a competition at the moment which seeks the next level, which will increase the complexity. It is an important role we are playing in setting the foundation for increasing complexity and more ambitious trials in the UK.

Lord Mair: Can I follow up? What do you therefore envisage? Do you think there are going to have to be trials for another five years, another 10 years? All three of you have explained very clearly that these are very initial trials and there is an awful lot more that needs to be done. We are trying to get a feel for what that involves. How many years of trials do you think will be needed before we can say this is going to be all right?

John McCarthy: I think the technology is probably there right now within car companies to do some level of automation. The question was asked in the earlier session about when it will exist. I think testing is a regime that will have to be in place in parallel with the technology to make sure that, as when new software comes out, when it has to be issued, you make sure that you validate it. We look to get to a state where we have a benchmarking around critical performance situations where we know what the technology would need to do, but I think testing, as

happens right now with ordinary vehicles, in that new vehicles come to the market and undergo rigorous test regimes, will continue for the world of connected and autonomy.

Q34 Lord Hunt of Chesterton: I was going to ask about the current trial you are planning in Milton Keynes and elsewhere. Presumably, you can programme an autonomous vehicle, if I may say so, to drive excitingly but within the law, stopping and starting like some vehicles, or very slowly. There is historical evidence about this. In Cambridge in 1910 there was the question of buses versus trams. The Conservatives were in favour of this new, nippy thing called a bus and the Liberals were in favour of trams, and the trams of course all went along tramlines. I was warned about this when I was a city councillor in the Sixties. Seriously, it is interesting. Presumably you can get some data and vary how people behave in autonomous vehicles, and that can answer or help decide whether a level of excitability of driving autonomous vehicle makes it more or less acceptable to the general public.

John McCarthy: There is a follow-on project in Greenwich called MOVE-UK, which is led by Bosch, and TRL, Direct Line insurance, and Jaguar Land Rover are partners in that project, and that is fitting a fleet of vehicles with automation systems. They do not act on the vehicle in any way, but they are there monitoring and recording what they would have done in the situations that the drivers encounter, so they are always human-driven but the automation systems are present. We will build up a big database comparing what the human drivers do and what the automation systems would have done, and, where there are differences, come to judgments about who was correct in that situation, to understand and improve the way in which we develop the algorithms that control an automated vehicle, and understand that variability in human driver behaviour.

Viscount Ridley: I am a notorious optimist. I think we harp on about the risks of new technologies too much and the benefits too little, but in this case there will be disadvantages as well as advantages. We all know the problem of the accident-prone but hyper-cautious autonomous vehicle that is going to mess up and congest the streets. How do we maximise the benefits and minimise the drawbacks, and is there a risk that at an early stage of the introduction of this technology, when, say, 15% of the vehicles on the road are autonomous, we are going to see all the disadvantages and not enough of the advantages?

John McCarthy: I think that is a very pertinent question. What we are looking to do within VENTURER is to look for the second trial to understand the engagement between autonomous and non-autonomous vehicles. You identified a scenario where a vehicle may not be, to use the word, “aggressive” enough in certain situations, where it is always waiting for a gap that will just not appear, which would cause congestion and tailback. It goes back to creating an intellectual awareness within the vehicle itself and within the control systems of the best performance in the best situation. I do not think an autonomous vehicle will always behave in exactly the same way in all situations, depending on the different parameters in place. If a vehicle is approaching at 10 or 15 or 20 mph, the vehicle has to be intelligent enough to make the call. That is part of the research, and part of what

Nick alluded to there, the algorithm creating that intelligence that sits within the vehicle. It is also important from the traffic management perspective that the vehicle does not exist in isolation; it has to be linked into how we manage the traffic at a local level, at a centralised level, and receiving information that makes the best decision, because ideally, based on that optimism—and I am a fantastic optimist as well—it is receiving information from all these different moving parts and allowing the whole city to perform more efficiently. That is what we are looking to achieve ultimately from this, while giving the excitement to the user.

Baroness Morgan of Huyton: Can I add to what Lord Ridley asked? I am interested in what you have found out so far about whether there are any—I was going to say quick wins—quicker wins where you think the public may be more instinctively interested and supportive of this new technology. I need to declare an interest. I am a member of King's College Council. I was not here last week.

John McCarthy: The first part of our work on the behavioural aspect of it will be released later this year. At the moment we are aggregating all the results. I think what comes out of the work that we have done so far is a little bit of fear linked into a little bit of novelty, linking intellect to the question of what I can get out of this. It is linking into the mindsets that people have traditionally around their transport choices, and seeing them re-imagining a future where something is going to be different, and connected and autonomous vehicles are part of that. The quick wins in this world are around the connected part of this CAV conversation, connected and autonomous vehicles—connectivity exists in a relatively stable way right now—and understanding what services we can offer to the individuals, to the traffic manager, to the different elements of supply chain that we can try and monetise that value. I think connectivity—and some of the panel members earlier mentioned this—co-operative ITS is part of the quick win. Also, looking at linking up the capabilities across all the different sectors that are involved within the UK would need to happen fairly quickly to allow the UK to be a leader in this emerging space.

Lord Vallance of Tummel: Some of these algorithms will be faced with moral questions, perhaps even life and death questions, or certainly questions of what makes people more or less happy. Who will make those judgments? Is it the engineers who do the algorithms? What criteria will be used? Or does somebody else make the judgment?

Professor Nick Reed: This debate on the ethics of decision-making by an automated vehicle is an interesting thought experiment, and it will be a practical challenge. Personally, my view is that there are two factors that mitigate the concerns I have about ethical decisions by automated vehicles: first, that the vehicles will be risk-averse and have a better understanding of the risk that exists in the driving situation, so they will be much less likely to encounter a situation where a collision is unavoidable; secondly, that the vehicles will be recording all the conditions that existed in any collision situation and we'll be able to audit the process that the vehicle went through that resulted in any collision. The courts will decide who is liable and whether the vehicle behaved in a way that was acceptable or not. If it was

unacceptable, it will be possible for all vehicles running that system to be updated, based on the decision-making around what is acceptable and not.

Lord Vallance of Tummel: Yes, but before the courts get at it, somebody has to write the algorithm. Who keeps a watching eye over the ethics of the algorithm?

Professor Nick Reed: The testing of automated vehicles will be different. It will have to be. We cannot just accept that a vehicle is tested on a sterile test track environment and then released into the wild. That was the logic behind setting up the living lab: we need test environments where you can address some of the complexity involved in driving in the real world. Having complex test environments will be important, and the ability to test the algorithms in a validated virtual setting. That is a big task: to create a validated virtual environment where you could present automated systems from supplier X and Y and compare whether one does better in foggy conditions or icy conditions. That is where we need to be heading.

The Chairman: I think we all understand that this will be safer—we expect it to be safer anyway. That is a reasonable expectation. We accept also that you can learn by experience, and if something goes wrong, any machine on that programme can ultimately be recalibrated, reworked, in order to take that into account. Nevertheless, we start with this ethical issue that there will be situations in which a choice has to be made between the safety of the passenger, for example, and the safety of a third party, and the question is: is society justified in asking somebody to write a programme which has ultimately to address that issue? That is not to say that it will not be an advantage, but have we the right to make people determine that decision, ultimately perhaps to be determined as to whether they got it right or wrong by a court?

Lord Cameron of Dillington: Or can society trust the motor manufacturers to take the right decisions, bearing in mind the post-Volkswagen fracas?

John McCarthy: I think “trust” is the key word here, and understanding how the system performs in different scenarios and situations. Linked to that, we face ethical questions right now as we drive as to what decisions we make and the consequences of our actions from our own individual perspective, not balanced against the perspectives of the other road users. We face ethical consequences of our actions as we drive today. This links back to safety, and we all expect and hope we will have a safer future on the road.

Underpinning all of this is a scenario called the trolley test—I do not know why it is called the trolley test but it is asking the question: do you kill the old person or do you kill the child? What we look to do, reflecting upon that real question, is understand what the individual will do now, as a driver facing those situations, and the consequences of that, and see whether we can create a system with the capability of making the decisions in advance of that scenario arising. That looks at predictive capability, aggregating the data, trying to reduce the chances of it happening, and when you are faced by that choice, that the vehicle is not going to make a situation—and we cannot walk away from the statistics—of five people dying every day in the UK.

Lord Cameron of Dillington: Still, an individual will be writing this algorithm, so that responsibility will rest as it stands, with an individual. If you look at the parallel with the medical side of things, with the National Institute for Health and Care Excellence, for example, there are ways of doing cost-benefit analysis which deal with ethical issues. You will have another set of ethical issues here, and I wonder whether there should not be rather more than leaving it to the guy writing the algorithm.

John McCarthy: I think that is a doomsday scenario, where one individual is dictating the choices of the car in all situations. Part of what we are doing now is starting the journey around connected and autonomous vehicles, particularly autonomous vehicles, to understand what the requirements would be for the creation of this algorithm, for the creation of the software, who validates the person's code, who validates the system's response, who takes a collective approach, and what that means from a legislative and regulatory perspective as well. That is all part of the conversation that is unfolding now.

Q35 **Lord Fox:** What timeframe do you think you are working to for the deployment of a level 5 automated vehicle, and what could speed up, or indeed, perhaps more pertinent, slow down that deployment?

Brian Matthews: In Milton Keynes we are looking to deploy the level 3/level 4 within the timeframe of the current programme, so within two years, and we are making good progress to deliver that. As mentioned, the next set of trials specifically asks for a level 4 capability to be deployed within the next two to two and a half years in all weather conditions on most highway types. The advances are coming very quickly. I heard the answer to the last question, and my view is that we will be at that level within five years.

Lord Fox: At what level?

Brian Matthews: Level 4.

Lord Vallance of Tummel: At what point during the trialling is somebody going to trial the vehicle-to-infrastructure telecommunications?

Brian Matthews: The trials in Milton Keynes through the connected vehicles do a little of that, in the connected vehicles to the connected infrastructure.

Lord Vallance of Tummel: Using what technology?

Brian Matthews: I am not a technologist by background but it is within the control system of the short range—my colleagues may be able to help—radio frequency between the vehicle and the control systems and the traffic signals of the road infrastructure.

John McCarthy: Typically, the technology that is used and that we would be looking to use is 802.11p, part of discrete short-range communications, called WAVE in other worlds. People see an advantage in this relating to the latency of the communications of the data and its resilience in certain circumstances, or in all circumstances. That has to be borne out from testing. The previous speakers talked

about 5G and ITS-G5; 802.11p is complementary to ITS-G5 as part of that spectrum of engagement on V2I, vehicle to infrastructure, and vehicle to vehicle.

Lord Fox: Can I come back to the question I asked, because I obviously got the Milton Keynes view. Is that view shared in the other two tests of level 4 in about five years' time and presumably 5 some time in the far distant future?

John McCarthy: I think, again, like Brian in Bristol and South Gloucestershire, we are looking at level 3, level 4 within the remit of this project. If you are asking when people will be safely using and at a high level of use, within the real world, I think you are looking within the next five to 10 years. I think by 2030 is the ideal to have level 5 automation. The challenge—I think you asked what would stop it taking place—is lack of trust and lack of benefit. The trust is with regard to cybersecurity, what the vehicle decides to do in certain situations, and I think that trust is really important in getting a customer-centric value associated with autonomous vehicles so we are not stuck in congestion and that the vehicle is offering us something different.

Professor Nick Reed: Similarly, we are looking at level 4 vehicles in Greenwich. It is really important to understand the distinction between the different levels of automation. A level 5 vehicle is the vehicle that does all the driving all the time, and is capable of doing any driving that a human driver is capable of. A level 4 vehicle can do the complete driving task but only under certain boundary conditions. Google, for example, is creating a level 4 vehicle because its vehicle will operate only where it has done sufficient mapping. If you wanted to take a Google car from California to New York, it would not be capable of doing it because the massive part in the middle has not been mapped by Google to the sufficient level of accuracy. Level 4 vehicles can happen in the timeframes that have been described, five to 10 years; level 5 is a much more challenging task and will be some time beyond that.

Lord Hunt of Chesterton: Can I ask Mr Matthews: you are going to do these tests; will all the cars have the same programme? As we said earlier, you can have more or less exciting or risky behaviour, so will there be different parts of Milton Keynes run on different programmes, let us say the kind of excitement of people over there, or the very geriatric people over there?

Brian Matthews: One of the features of the programmes we are all involved in is collaboration, and that is a condition of taking these forward. The motor manufacturers, the OEMs, in Milton Keynes, which are Ford Jaguar Land Rover and Tata, are all collaborating and the vehicles talk to each other. Our trials in Coventry and Milton Keynes will see, I think, six vehicles over 12 days operating on the network.

Lord Hunt of Chesterton: Always in the same framework?

Brian Matthews: Yes, in the same framework, the same routes; we have to specify routes, and we have picked challenging cross-city routes in both locations. The vehicles will demonstrate their level 4 capabilities, with a driver ready to take over should anything happen—a safety man, so yes, there is good co-operation between the motor manufacturers in this project, and I believe it is the same in the others.

Q36 Baroness Morgan of Huyton: Can I ask you a little bit more about what you have found out yet about what new infrastructure and investment you think will be needed? Obviously, you are all involved in practical testing at the moment. What is already there and what will definitely be needed? In our previous session obviously we heard about 5G, and since a lot of the country does not even have 4G, I wonder what areas we ought to be focusing on? Or 3G or any G.

Lord Maxton: No G.

Professor Nick Reed: My view is that automated vehicles will happen, regardless of the level of investment in infrastructure, but the pace of deployment can be enhanced by having an infrastructure that is adapted to their presence. I think it comes down to what kind of mobility we want to achieve. Particularly thinking about the city environment, we are very conscious in our trials that we do not want the development of an automated vehicle service to detract from the work that has been done to encourage active travel; we do not want a convenient automated service to replace journeys where people might have chosen to walk or cycle. Making sure the infrastructure complements the way in which we want mobility to be achieved, certainly in the urban environment, is what we are focused on.

John McCarthy: To build on that, there are two threads within the autonomous world; one is that there will be no dependency on infrastructure and one is that there will be a very strong dependency on infrastructure. I think those two worlds are still emerging as to what the impact will be. From an infrastructure perspective though, the UK's recent work on how we rate relative to the rest of the world and the need for investment within infrastructure, currently we are ranked 24th. That is the figure that was mentioned. It seems to me that if we want to be a leader in autonomous vehicles, if we want to be a world best, we have to have infrastructure that is world's best. What that infrastructure will be is yet to be determined.

Baroness Neville-Jones: What is your best guess about what kind of infrastructure you think people would go for?

Professor Nick Reed: I think it needs to be consistent. That makes it easier for the vehicle manufacturers or the system designers.

Baroness Neville-Jones: It has to be interactive possibly?

Professor Nick Reed: I do not think necessarily.

Baroness Neville-Jones: Not necessarily.

Professor Nick Reed: Not necessarily. There is benefit to management of traffic if there can be communication between vehicles and with infrastructure, and you would focus investment on the busiest routes to make that possible.

Baroness Neville-Jones: When you say it has to be consistent, are you saying that is so that the vehicle can recognise it, know what it is?

Professor Nick Reed: Yes, so that it can localise and understand the environment in which it is.

Baroness Neville-Jones: So you have to have standardisation of shapes and models

of road furniture?

Professor Nick Reed: They are pretty well standardised already.

Baroness Neville-Jones: Is it?

Professor Nick Reed: Yes. Road designs are—

Baroness Neville-Jones: There are tons of things on the roadside that are not standard: crash barriers, et cetera.

Professor Nick Reed: A vehicle that has a digital map, so it understands its environment digitally, does not need any infrastructure; it does not need signs to tell it that it is a 30 mph limit; it knows from its location that it should be operating at a certain speed, and that applies to lane markings as well.

John McCarthy: On that point, I think typically when we talk about infrastructure we think about the physical, but in the world of autonomy and autonomous vehicles we have to think about the physical infrastructure and the virtual infrastructure, which is around the data side and the communications, and how we harness that data. From the physical perspective, it is whether road layouts that exist now are fit for purpose for the future, what exists and what might not be needed. I think the intelligence can be built into the infrastructure to allow conversations to take place as and when needs be, so that, particularly in safety-critical situations, the assets, the vehicle, the individual and the infrastructure can communicate with each other. From the virtual side, we need the ability to harness all this data and make sense of it, because we are migrating into an unbelievably data-rich world, and what we use it for and how we get benefit out of it is for us to try and understand in partnership with everybody else.

Brian Matthews: If I could add on the infrastructure point, with the low-speed pods we are operating in Milton Keynes, we are very confident and we have demonstrated they can operate with no infrastructure, but we recognise—and it is a point Nick made—that we have to support the needs of other travellers, so the infrastructure we are looking for is to support the cyclists, pedestrians, and other road users so these two systems can co-exist. A separate piece of work working with European partners is a project called Co-Exist, to try to understand what infrastructure requirements there are in the short term to allow the transition from the fleet as it is now to the fleet in the future, and provide some guidance and toolkit for highway design teams to understand what is needed in the short, medium and long term.

Lord Oxburgh: These are electric cars, are they?

Brian Matthews: The pods in Milton Keynes are powered by electricity, yes, but the cars are standard cars.

Baroness Neville-Jones: Does the speed at which a vehicle is travelling affect the calculus at all? Do you need more interactivity if you are going at greater speed to get more advance information, or do you not think that is a relevant consideration?

Professor Nick Reed: The speed has more of an influence on the quality of the sensors and the speed of processing of the data that it is able to collect rather than connectivity.

Q37 **Lord Hunt of Chesterton:** Have your trials been assisted or impeded by the current regulatory regime? Are you making recommendations for it to be changed?

Professor Nick Reed: The code of practice for testing automated vehicles that the Department for Transport introduced post-dated the award of the projects, so we all had the opportunity to influence the creation of that code of practice. We were thinking very much about how the code of practice would support the implementation of the GATEway project and the 10 other research projects we felt were important to be undertaken in the next three to five years. The regulatory environment has been supportive and we have been in regular dialogue with CCAV on how results from our trials can influence the changes to that regulatory world.

Lord Hunt of Chesterton: Is it quite similar to what they are doing in other European countries?

Professor Nick Reed: The point was made in the previous session about the differences in approach to the Vienna Convention on Road Traffic. That other European countries are doing everything they can to enable testing of automated vehicles in their own territories is bound to be happening, and certainly the Netherlands, Germany and Finland, I would say, are very active in the testing and development of automated vehicles.

John McCarthy: As part of the work within VENTURER, our team is made up of AXA insurance, complemented by Burges Salmon looking at the impact of autonomous vehicles in a regulatory way, understanding what the impact might be from a policy perspective. It is an ongoing engagement to understand what those impacts might be and how it relates to questions which have been raised here in different ways. I think the regulatory framework as it exists right now allows for testing. You must understand what can be possible for true deployment, ongoing engagement and full usage within the real world. That is part of the work we are looking to do across the three different trials, to understand from the technology perspective it is a complex scenario, but from an insurance perspective—and we talked about product liability rather than individual liability—the impact from a regulatory framework. That is what we look to do across trials two and three.

Lord Hunt of Chesterton: Does the fact that we are already number 25 in this list of countries in the world with infrastructure, as opposed to number one, make a difference to how you are developing these regulations? I can imagine in a country on average with poor infrastructure you would do things differently.

John McCarthy: I think they are linked. I do not believe they are intrinsically linked with regard to the regulatory aspect. The performance requirements and possibilities associated with autonomous vehicles having the right infrastructure—and we have to debate what that is—is a conversation that will take place anyway.

Lord Cameron of Dillington: Are we leaders in this field? Could we become leaders

in the field, and what do we need to become leaders in the field? To what extent is information globally available between you and trials going on in other countries?

John McCarthy: We approach connected and autonomous vehicles as part of the bigger conversation, and that is around intelligent mobility; it is about engaging people, places and goods and re-imagining infrastructure. Are we leaders in the overall field of connected and autonomous vehicles? Within elements of it we probably are. The supply chain and the different parts that make up the conversation are huge. What we look to do within this piece is take a leading step within the understanding of user requirements, of the behavioural aspects, certainly from a VENTURER perspective, and from complementary works we have done, so a separate project, Flourish, looking at connected vehicles and the impact on the city, and the needs of the older population through the use of new technologies. I think we can lead in certain aspects, and it has to come back to the capabilities of the UK.

Connected and autonomous vehicles is a massive cake; I do not think we can eat all of it. I think we should look to have the vital ingredients, to use that analogy, to make sure that people will want to come to us. I think the testing environment allows that to happen because, first of all, it is real; secondly, the testing environment itself is real; thirdly, the innovation this country offers is respected globally and we should build upon that. That is what we are all looking to do within our three projects and the others that are mentioned.

- Q38 **Baroness Young of Old Scone:** I think you have already partially answered the question about whether the testing regulation can be UK or needs to be European or international, but on operation for the future, do you think we can develop any of our regulation alone or does it have to be a global system?

Brian Matthews: We are certainly starting to talk to international partners on these topics. We have recently undertaken a roundtable discussion with cities in the US, Australia, Singapore, and Sweden around these issues, and the feeling around the table is that it has to be collaboration. That is not to say they were recognising that the UK in many of these fields is ahead of the game, and there is as much to learn from us as we can learn from them, but I believe it needs collaboration and we are taking steps to bring that forward.

- Q39 **The Chairman:** You have described to us the three projects that you are involved in, and indeed there is a fourth soon to start. To what extent do you pool the evidence that you have accumulated and to what extent do you help each other out?

Professor Nick Reed: In the three projects we were competitors for the funding at the start but, having been awarded funding, we collaborate. I would say to date it has been more about getting our trials up and running. We have been busy making sure we are hitting our timescales for technical delivery, but now that we are starting to deliver our trials, there will be more opportunities for us to collaborate and share data that is emerging. There is also a DfT-funded project to collect the social and behavioural outcomes from the three projects, integrate that and look at the emerging patterns from the three trials.

John McCarthy: In early December there is a further event organised, where all the winners within the space sit down and engage with each other, because the worst-case scenario is that we create silos of excellence. The benefit is across all of these areas and, as Nick said, we were competitors but now we are building on the capabilities, and with the separate project and the event in December, now that we have gained traction within our projects, we are probably at a level where we have something concrete to begin talking about and sharing our learnings and knowledge.

Brian Matthews: That certainly is a good point. When we started the projects everybody was very excited and wanted to see an autonomous vehicle the next day; the reality was they are not appearing for another six months or so. It seemed as if we all went into our shells but, as has been said, we are collaborating more openly now. Within the Autodrive project there is a work package for dissemination of the results, and that is key for us to get out there what our learnings are and share the results.

The Chairman: Unless anyone has a burning question they wish to put, we have probably run out of time, as usual. It has been a most instructive session and we could have continued at great length, particularly hearing more about tests around the world and to what extent they complement your activity. Time is against us. Thank you very much for helping us this morning. There will be a record of the deliberations circulated to you, and please make any amendments if the record is inaccurate. On behalf of the Committee, can I thank Professor Nick Reed, John McCarthy and Brian Matthews for joining us today? Thank you very much.