Meeting of the Parliamentary and Scientific Committee on Tuesday 16th June

ELECTRIC CARS

Lord Borwick
House of Lords

Cars represent freedom. You have the right to get into your car for any reason at any time and go where you want, subject only to cost. An electric car with no charge will take away that freedom from you, and many consumers will resent that.

So if we want to see our road network covered with electric cars, then we need further improvements in technology.

But the development of electric vehicles is nothing new. I was the Chief Executive of Manganese Bronze Holdings for 14 years, where we made London black cabs. We made the TX1 London taxi – the new standard London Taxi – diesel powered, with the idea of converting it to electric later.

The key to the success of the TX1 London Taxi was its wheelchair accessibility, but actually this provided space underneath the flat floor, needed for the wheelchair, for siting batteries. However, my first priority was to make the taxi drivers rich by making a great taxi, but what I did not focus on was that rich drivers would move out to the suburbs. The effect of this was that many drivers have a lot of dead mileage before they start earning their living in London, meaning a hybrid is a better solution for their vehicles' needs than a pure electric vehicle.

The Modec van, however, was a pure electric delivery vehicle with a two tonne load and a 100-mile range, which worked on the basis that there is no range anxiety among the delivery companies. FedEx and UPS were two of our biggest customers for the Modec van. They can plan their routes with great accuracy and so they know how many miles their drivers would be doing every day. UPS warned us that in America, driving on the right hand side, they would do ten times as many right hand turns as left hand turns and we should design the steering system accordingly. This of course had

Modec van in London ©Modec

When I sold out of that business in 2003 I started a new electric delivery vehicle business called Modec and I also become chairman of a battery company called Oxis.

an impact on the range of the vehicles.

This question of range anxiety for vehicles has a long history. Indeed, electric vehicles were far more common than petrol ones at the end of the 19th century. In 1905 if you compared the very common electric vehicles with the awkward and dirty petrol ones, the driver with the range anxiety would have been the man wanting to buy petrol.

At the start of the 20th century most people would have predicted that electric vehicles would be far more common than the internal combustion engine vehicles by the start of the 21st century. Petrol and diesel cars clearly took over for many decades but as politicians – and consumers – become more conscious of the environmental impact of the combustion engine, a lot of resources were ploughed into the development of a new wave of electric cars, including various types of hybrids.

The first effective one of these was the Toyota Prius, and the company made two brilliant moves when introducing this car which are lessons to remember. The first was to ensure that the vehicle had a different body shape so that it was distinctive; it enabled the driver to boast visually that he was doing something better – and possibly more virtuous – than other drivers. (Honda, on the other hand, made their first hybrid in the same body shell as their small saloon and consequently sold very few of them.) The lesson is that it is useless to be good unless everybody knows it – ask any two year old.

... the future of electric vehicles depends on the future of batteries ...

The second brilliant move by Toyota was ensuring that the Prius was allowed to travel in the car pool lanes on Californian freeways. A second hand Prius with one of these stickers on the window was worth about $2,000 more at five years old. Perhaps the lesson here in the UK is to allow electric cars into bus lanes.

To achieve success in the longer term, the electric car really has to beat normal petrol or diesel engine vehicles, so studying the competition is important. For instance, a feature of all internal combustion engines is their exhaust pipe, which are made as attractive as possible with chromium plating and placed low down at the back of the vehicle. This is the one point where the driver cannot see them, but that is the place where they feed their fumes into the faces of bicyclists and children on the pavement. Exhaust is, of course, poisonous, and this poison comes in many forms; no longer filled with lead, but it is the diesel particulates that we should worry about most.

... the electric car really has to beat normal petrol or diesel engine vehicles ...

Over the last ten years there has been constant and justified attention to carbon dioxide, but a single minded pressure on reducing CO_2 meant new cars used diesel. This then led to more particulates in the air.

As the efficiency of diesel engines improved, PM2.5s increased (particulate matter less than 2.5 microns in size) and only later did we discover that these particulates bypass the throat and go right down into the lungs where they can cause most damage. If somebody wants to clean up the air we could do worse than put the exhaust pipe at the front of the car, where the driver would see it and feel pressurised to do something about it.

The bottom line of the internal combustion engine is that it is very, very complex and has had millions of engineers working many hours to improve it. Each one may have many thousands of components. The electric motor would probably only have three components and not require any maintenance. So why has it not conquered the world? The answer is because petrol and diesel are very hard to beat. When you pour petrol into your car at the petrol pump you are transferring energy at a rate of about 30 megawatts. That means that a 20-pump petrol station beside the road has the power output of a modern nuclear power station. Electricity at 30 megawatts would need a 300 mm wide cable and be far more dangerous.

In the long term, the future of electric vehicles depends on the future of batteries. Right now, they come in two major types – the stationary and the moveable. The stationary batteries include pumped storage, the marvellous system we have in Dinorwig in North Wales. The obvious moveable battery is in your mobile phone. It is lithium ion, the major type of batteries developed in the UK in the late 1980s and early 1990s.

In the lithium ion battery, power density and energy density improved rapidly. But new technologies develop most quickly at the start of their lives, and the law of diminishing returns is now starting to apply. So we have to look at other chemistries to make our future electric vehicles. The two chemistries that immediately come to mind are lithium sulphide and lithium titanate.

There are five features of a battery that must be optimised. The first is the speed of discharge, essentially the power output of the battery. The second is the speed of the charge. The third feature is the number of charge cycles I can do. All the pure electric car companies have agreed that they need a minimum of 1,000 charge discharge cycles. The fourth feature is the temperature stability and how its performance varies in tropical or arctic conditions. The final feature to look at is how close to the capacity edges you can get without ruining the longevity of the battery.

Of course, all of this makes it harder to produce and test a new battery. If I were to invent brilliant new battery chemistry tomorrow, I cannot start selling it for at least three years. With pave testing, where you rattle the suspension of a car on a single mile of cobbles, this is equivalent to 100 miles of use. But nobody has yet developed a robust and accepted "accelerated cycling" test algorithm for batteries.

Having said all that, some great work has been done on lithium titanate and there are apparently several manufacturers prototyping vehicles with a 300 mile range, quite enough to abolish range anxiety and enable electric vehicles to take their place in the market.

But the rewards for whoever cracks it will be huge. Low speeds make an electric car the perfect car for a teenager or elderly driver. And for a teenager, the electric car is cool. It is new technology that can be marketed at an environmentally aware young audience – another piece of the latest kit to go with their smart phones and tablets. Electric cars will, in time, be the new vehicles of freedom.

AUTOMATED VEHICLES

Rob Wallis
Chief Executive, Transport Research Laboratory (TRL)

Professor Nick Reed
TRL Academy Director

INTRODUCTION

TRL, the UK's Transport Research Laboratory, was created in 1933, originally as part of UK Government, and privatised in 1996.

A world-leader in creating the future of transport, our heritage includes major contributions to the UK's transport infrastructure and international projects supporting established and emerging markets in developing transport solutions. Our in-depth sector experience provides the insight to recognise an approaching revolution in transport and mobility, driven by acceleration in the development of connected and automated vehicles and triggering safer, more efficient journeys but also dramatic, broader changes in the movement of people, goods and services with far-reaching implications.

REALISING THE VISION OF AUTOMATED VEHICLES

In 2010, Google announced that they had been testing self-driving cars on the road, gaining substantial media attention. TRL has been evaluating automated driving for many decades, starting in the 1950s with a 'self-steering' Standard Vanguard. TRL's system used two coils mounted symmetrically across the front bumper to detect offset of the vehicle from an electric cable buried in the centre of the lane under the road surface. This technology was adapted to a Citroën DS, Ford Cortina Mk II and even a Daimler single-decker bus. Coupled with a rudimentary cruise control system, these vehicles were able to drive themselves; initially around TRL's test track. Plans for on-road testing were ultimately still-born. Technology has progressed significantly. The implications for legislation, economic impact and driver behaviour have been researched by TRL in many dimensions.

In 2014, Innovate UK launched the 'Introducing Driverless Cars to UK Roads' competition. This was not in order to fund the development of new technologies, but to consider the wider implications of automated vehicle deployment. TRL's reputation for independent, trusted and technology-agnostic research allowed us to develop and lead the successfully funded GATEway (Greenwich Automated Transport Environment) project. GATEway includes eleven organisations, each bringing specialist knowledge and capability to the project. It is supported by an advisory group, chaired by Lord Borwick, and includes more than twenty organisations, each feeding diverse insights into study design and the interpretation of results.

GATEway has six primary aims:

1. Demonstrate automated vehicles safely and effectively in public environments.

2. Understand legal, societal and technical barriers to implementation.

3. Inspire industry, government and the wider public to engage with automated vehicles.

4. Generate valuable, exploitable knowledge of the systems required for effective management of automated transport.

5. Create a long-term test bed for future automated transport system evaluation.

6. Position UK plc at the forefront of global industry, encouraging inward investment and job creation.

In achieving these, the project must demonstrate and evaluate automated vehicles. This will be achieved in three public trials. Firstly, testing electric, driverless shuttles each capable of carrying up to 10 passengers and operating as a service on the Greenwich peninsula; secondly, automated valet parking to improve parking space and time efficiency and thirdly, the use of automated, low noise and zero emission vehicles for urban collection/delivery. Further, we will address cybersecurity issues and conduct off-street simulations and trials, gaining deeper knowledge about public perceptions, driver behaviour and attitudes towards automated vehicles.

CREATING FUTURE MOBILITY

Beyond the GATEway project, TRL worked with Ricardo on a feasibility study for the Department for Transport looking into platooning of trucks on highways, potentially leading to on-road trials. We are also researching the deployment of ultra-low-emission vehicles (ULEVs) where battery range remains a challenge. TRL is leading another consortium on behalf of Highways England to conduct a feasibility study into dynamic wireless power transfer. This concept would enable a vehicle to charge its batteries inductively while the vehicle is driving at motorway speeds, dramatically increasing vehicle range and the viability of large, commercial ULEVs.

Working with the European Commission, vehicle manufacturers and the automotive supply chain, we systematically reviewed more than fifty vehicle safety systems such as autonomous emergency braking, lane departure warning systems and alcohol ignition interlocks, providing evidence to support possible changes in legislation. We are also engaged in the push for harmonisation of global crashworthiness standards, linked to our heritage in developing these standards over many decades and founding the EuroNCAP protocol in 1996.

TRL Autonomous driving 1962

Air quality has an increasingly high priority. TRL has pledged support to the United Nations-sponsored Urban Electric Mobility Initiative, which aims to achieve 30% of urban vehicles as ULEVs by 2030, with an anticipated multi-trillion dollar benefit to the global economy through reduced fuel costs and improved public health. A tangible example of where TRL is seeking to make an environmental difference in the UK is the integration of real-time air quality satellite data into our world-leading SCOOT traffic management and signal optimisation software, working with the University of Leicester, the European Space Agency, and relevant Local Authorities.

In the push for improved public health, we should not forget that walking and cycling have health benefits – automated vehicles should not discourage these activities. We have undertaken research into safer urban cycling behaviours to help TfL drive the Mayor's vision to double cycling in London by 2020.

AN APPROACHING REVOLUTION

There are divergent expert opinions on how road transport will change in the next ten years, with new business models challenging the established mobility sector.

Considering vehicle automation, will we see:

a) driver assistance systems evolve leading to a proliferation of partially automated vehicles, with a driver still present and no prospect of full automation for many years? Established vehicle manufacturers are pursuing this model.

b) or mass adoption of fully automated and driverless vehicles, especially in urban areas, bringing major market disruption by non-traditional players such as Google, Uber or Tesla? Mass changes in vehicle ownership models may influence public transport, deliveries and manufacturing with significant re-shaping of the employment market.

Considering ULEVs, will we see:

a) a revolution in propulsion – a breakthrough in battery technology or the development of practical fuel cell EVs enabling vehicle range that matches or exceeds that of vehicles with combustion engines.

b) improvements in battery technology while traditional combustion-engine vehicles remain dominant – driving the necessity for smart infrastructure, including fixed/dynamic wireless charging? Will businesses adopt automated ULEV vehicles, optimised for smooth and safe freight journeys through urban centres, using wireless power technologies?

These new emerging technologies create opportunities for the UK and for industry, but acceleration is required to remain relevant and competitive. The US provides examples:

... reduced fuel costs and improved public health ...

a) Uber emerged in five years to have millions of clients, operating in 300 cities globally. While their business model is causing friction in established markets, Uber is now investing in automated vehicles to enhance their service radically.

b) Google has been trialling its driverless cars for some time, with over 1.7 million miles covered on Californian public roads. This in itself is revolutionary but is just one dimension of profound advances in artificially intelligent system development.

c) Tesla is pushing electric car capabilities, investing heavily in battery technologies, including its planned 'Gigafactory' in Nevada. They will apply an over-the-air update to existing Tesla vehicles to enable automated driving on highways.

What are some inspiring implications of this revolution? A few observations:

1. The UK Driving Test is 80 years old; TRL plays a major role in its ongoing development. How will this evolve as vehicles become automated? Will it become obsolete?

2. Can roadside infrastructure be removed – supplanted by in-vehicle information displays and automated driving? Does the windscreen become a viewing gallery rather than giving the driver a critical view of the road ahead?

3. How will automated vehicles operate amongst manually driven vehicles? Will they act aggressively to optimise journey-time (for a fee?) or passively to maximise comfort and network efficiency? Will they exacerbate road rage?

4. Road vehicles are developed to withstand crashes (caused mostly by driver error). Reduced crash risk and differences in crash types might prompt a re-think into the design, materials, weight and cost of such vehicles.

5. How will technology developers make decisions about codifying driving style and ethics into software? How will automated vehicles make instant, safety critical decisions?

TRL actively supports the UK and industry to participate and shape this revolution in the global transport and mobility marketplace. It is pleasing to see further UK Government investment and related activity in vehicle automation and connectivity to support advances in journey safety and efficiency and stimulating a hugely significant market opportunity.

THE FUTURE OF ROADS AND CITIES

Steve Yianni
Chief Executive
Transport Systems Catapult

INTELLIGENT MOBILITY: AN ECONOMIC OPPORTUNITY

Britain has a long history of transport innovation: from the shipbuilders who paved the way for globalisation, to the railways that underpinned the industrial revolution. We pioneered the era of modern aviation, the airline industry, air traffic control and even the development of radar. Britain is still a world leader in transport innovation, and the Transport Systems Catapult is positioning the UK at the forefront of the next revolution in how we move people and goods around the world.

Encompassing everything from autonomous vehicles to seamless journey systems and multi-modal modelling software, Intelligent Mobility uses emerging technologies to enable the smarter, greener and more efficient movement of people and goods around the world. Intelligent Mobility is a fast growing sector with the global market estimated to be worth £900 billion a year by 2025.

The Transport Systems Catapult is helping the UK secure as much of this market as possible by supporting business, creating jobs and driving economic growth. With a clear emphasis on collaboration we are bringing together diverse organisations across different modes of transport, breaking down barriers and providing a unique platform for meeting the world's most pressing transport challenges.

The common goal is to develop future transport systems that will make;

- Travelling an end to end, user centric experience
- A positive impact on our carbon footprint
- Travel safer and quicker making assets more productive
- The UK generate a larger share of the economic opportunities available
- Our transport systems more resilient
- Improvements to mobility for all areas of society

Intelligent Mobility is about taking a different approach to the challenges that have traditionally beset the transport sector, whether it be congestion, pollution or the lack of "joined up" thinking between the different modes of transport. It goes further than that, however, by also helping the transport industry to address wider societal trends including a growing and ageing global population, climate change, the rapid depletion of our traditional energy resources, the shift away from personal cars to mobility as a service and increasing urbanisation.

In order to meet these challenges, Intelligent Mobility has to cut across and go beyond the traditional transport sector. Intelligent Mobility therefore focuses on new and emerging technologies that make it possible to achieve more for less.

SMART AS STANDARD

The business demand for co-location of like-minded organisations and people presents significant challenges for those in charge of city planning and infrastructure. Technological advances in areas such as augmented-reality and 3D printing could soon render some of our journeys and deliveries as unnecessary but the smooth movement of the growing numbers of people around the world's already congested cities won't be solved by technology alone. It is how we deploy technology that will determine which cities prevail. Transport should be regarded as a key enabler to cities becoming smart and by overcoming barriers such as business models and attitudes to change, we can start to unlock the potential of such technologies.

... shift away from personal cars ...

One example of this is how the Transport Systems Catapult is working collaboratively with Milton Keynes on these challenges. Whilst the city has experienced great economic success, the challenge of supporting sustainable growth without exceeding the capacity of the infrastructure, and ensuring achievement of key carbon reduction targets, is a major one.

To help address these challenges, the collaborative initiative MK:Smart (partly funded by HEFCE) is developing innovative solutions to support economic growth in Milton Keynes. Central to the project is the creation of a state-of-the-art 'MK Data Hub' which will support the acquisition and management of vast amounts of data relevant to city systems from a variety of data sources. These include data about energy and water consumption, transport usage, data acquired through satellite technology, social and economic datasets, and crowd-sourced data. Building on the capability provided by the MK Data Hub, the project will innovate in the areas of transport, energy and water management, tackling key demand issues. Similar projects are under way across the UK which collectively will start to unlock new business models and enable innovative technologies to emerge.

MK:SMART

Many projects are informed by and feed into the Transport Systems Catapult's data visualisation programme, which by deploying and visualising data holds huge potential for Intelligent Mobility. This enhanced use of data is only possible because of the explosion in digital connectivity and as this paves the way for transport connectivity. The Transport Systems Catapult is unique in its approach, identifying the barriers that hold back modelling and visualisation true potential. High on its hit list is the 'silo approach', where key individuals, departments and organisations fail to share valuable information with each other, thus mitigating the potential of data modelling. By 2020, the market for data, modelling and analytical tools and techniques is set to grow to £60 billion from £15 billion in 2014. The market size, comprising modelling, simulation and augmented reality, is some £125 billion. The UK is an international leader and has a strong professional services industry. The Transport Systems Catapult's work is about equipping the industry to maintain this world leading status.

REALISING THE BENEFITS

As champions of Intelligent Mobility, the Transport Systems Catapult and its partners are taking advantage of developments in web connectivity, integrated systems, state of the art modelling and visualisation, and the emerging Internet of Things to change how we think about the movement of people and goods.

The LUTZ Pathfinder programme, managed by the Transport Systems Catapult on behalf of the UK Automotive Council, will trial three self-driving pods on the pavements of Milton Keynes, with a focus on 'last mile' journeys. The advent of autonomous vehicles is expected to change how we perceive car ownership. Instead of seeing the car as a status symbol, people are likely to regard it as an on-demand service which must accommodate our schedules in an efficient, safe and eco-friendly manner. If vehicles can be made to run entirely without human drivers, automation could also offer a new lease of mobility to those who cannot currently drive, whether on account of age, disability or simply because they do not own a car.

... Introducing Driverless Cars ...

Proof of the UK's willingness to invest in this area can be seen in the three projects exploring these technologies as part of the Government's 'Introducing Driverless Cars to UK Roads' competition announced in December 2014. These three programmes already represent a public private partnership investment of £40m. In March 2015, the Government announced the creation of a £200m investment (half financed by the State and half by industry) to enhance the development of driverless car technology and the systems required to improve and adopt the technology.

... save over 2,500 lives annually ...

Connected cars also take away the element of human fallibility, which is estimated to be at least partly responsible for more than 90 per cent of road traffic accidents. A study from KPMG, commissioned by The Society of Motor Manufacturers and Traders predicted that connected and autonomous vehicles would save over 2,500 lives annually and prevent more than 25,000 serious accidents in the UK alone.

Studies undertaken by the Department of Transport highlight a significant reduction in the number of 17 to 20 year olds obtaining a driving licence with data showing a peak at 48% in 1993 and a steady fall to 31% by 2011. The data for 21 to 29 year olds is a similar proportion from 75% to 63% over the same period. The growing popularity of usage rather than ownership will see new business models begin to emerge, with the diversification of the traditional car manufacturer potentially moving towards the operation of models such as fleet management of autonomous vehicles and car sharing clubs.

Recent improvements in route planning software that consider multiple transport modes is an example of the first steps being taken towards overcoming some of the challenges to mobility becoming a service, but there is still a long way to go. Part of our remit at the Transport Systems Catapult is to overcome the silo thinking that has typically dogged the transport sector and encourage collaboration among all transport providers and modes.

As we progress closer to Intelligent Mobility, the benefits will become increasingly clear. Reduced congestion, fewer car related deaths, an easing pressure on our natural resources and more flexible journeys to name a few. A myriad of opportunities are there to overcome some of the barriers and challenges that stand in the way and the Transport Systems Catapult looks forward to helping technology and society to catch up.