



Autonomous Vehicles:

A thought leadership review of how the UK
can achieve a fully autonomous future



Introduction

The idea of highly automated or autonomous vehicles is not new, however, the landscape has been transformed over recent years with the application of advanced sensors, communication technologies and databases. Autonomous systems are already pervasive, particularly in aerospace with autopilot on planes and military drones.

The Institution of Engineering and Technology (IET) held a debate this year with over 50 thought leaders from academia, industry, policymakers and research organisations to discuss the challenges and benefits around bringing autonomous vehicles technologies to the mass market. Part of the debate addressed the IET's role in advancing public policy and perception around these technologies, as well as engaging with government and industry.

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Acknowledgements

Professor Phil Blythe, University of Newcastle
Attendees of IET Transport Sector Thought Leadership Debate on Autonomous Vehicles

References

- ¹ Average cost of insurance for drivers aged 17-18 years, ABI, 2013
- ² Facts on Young Drivers, April 2014, Department for Transport
- ³ Driver licence data by gender and age (FOIR 2838), January 2012, DVLA
- ⁴ DriveLab, Digital Institute, University of Newcastle



Expert view

A keynote speech was given at the debate by Phil Blythe, Professor of Intelligent Transport Systems, and Director, Transport Operations Group at the University of Newcastle.

Professor Phil Blythe shared his thoughts on the technology, some of the issues and their possible solutions, highlighting that most people did not realise that driverless trains were already running, such as the Docklands Light Railway and Copenhagen Metro. Autonomous cargo ships are expected within the next 10 years and underwater autonomous vehicles are already in widespread use. The technology is already around us so what will be the game-changer for scaling up adoption?

Key findings

A system of systems approach was needed to connect all the different disciplines, manufacturers and nations together, with a person or body acting as an architect deciding on the rules and conventions across the world. The meeting had expressed a high level of confidence that autonomous vehicles would become more pervasive.

The challenge was more in full autonomy, opposed to closed or semiclosed environments, where there was less interaction with the wider public. Until mixed mode technologies could be widely tested, talking about 'assisted' rather than 'autonomous driving' might help the public get used to driverless vehicles on the roads.

The UK has developed skills that could be applied to cyber security and complex systems. Many of the examples from the debate came from software-related technologies. The UK has also been successful in

developing standards that could provide a framework for innovation and a platform by which small and large companies could add value.

The IET could play an important role in bringing together all the stakeholders who might benefit from the effective deployment of this technology, so that ideas could be compiled and reported to Government.

Role of the IET

The IET can play a very important role, in ensuring that stakeholders who have an interest and ultimately will benefit from the effective deployment of this technology are brought together, so debate can happen and ideas can be exchanged.

As a multidisciplinary organisation with established relationships in industry, at a time where industry sectors are looking at how learnings may be applied to the sector, the IET could make introductions and encourage collaboration to avoid reinventing the wheel.

Many of the software technologies we have today could be applied to this autonomous world. The IET is well placed to facilitate and encourage that debate, and will indeed ensure that we are listening and feeding back to Government the role we are playing.

There is no doubt that the IET recognises its responsibility, together with its stakeholders in industry and academia, to ensure that the debate happens rather than relying on Government to take the leading role. It is our responsibility to see these technologies brought to market, and to do this for ourselves.

Background

The concept of highly automated or autonomous vehicles is not new, but has been around almost since mechanical vehicles were invented.

What is new, is the range of technologies that are available to us which allow the concept to be taken to new levels of technical performance and sophistication. The revolution in the ICT industry has provided powerful sensors, navigation and information processing power which has transformed the nature of R&D, and application potential.

The general public will not realise how pervasive autonomous systems already are. Most flights on an aeroplane are on autopilot; you may well drive a car that applies certain 'automatic' systems during a journey. The technology is already here, but public awareness of it is very low. Some myths and legends are still restraining the deployment of these technologies.

Particularly in the aerospace sector, autonomous vehicles are often coupled with military applications or so called 'drones', which has not helped the debate. People see a sinister side to those autonomous technologies, but the reality is, that they can be safer and more efficient than manually controlled systems. The problem comes when you start to mix the two, and expose the wider public to these technologies.

The Institution of Engineering and Technology held a debate with over 50 thought leaders from academia, industry, policymakers and research organisations to discuss the challenges and benefits around bringing autonomous vehicles technologies to the mass market.

There is already a lot of technology at our disposal, but perhaps the most critical obstacle to bringing autonomous vehicles to reality at a large scale is using public policy legislation and regulation to create the environment in which these technologies can be deployed. In addition to debating some of the technical challenges, attendees were also encouraged to discuss potential solutions for public policy adoption.

Being an independent and impartial professional body, the IET is interested in engaging with Parliament, and public and regulatory bodies, as well as industry and academia, in moving forward the technology and public policy debate. Engineers and technologists are at the forefront of shaping solutions to the major challenges of today and tomorrow, and they have the ability to develop and implement complex and robust systems to meet the needs of society.

Keynote

In his keynote speech, Professor Blythe shared his thoughts on AV technology, some of the issues and their possible solutions, highlighting that most people did not realise that driverless trains were already running, such as the Docklands Light Railway and Copenhagen Metro.

Autonomous cargo ships are expected within the next 10 years and underwater autonomous vehicles are already in widespread use. The technology is already in use around us so what will be the game-changer for scaling up adoption?

Even Dyson is bravely predicting that, within 10 years, everyone will have a robot in their house. Moving towards this intelligent autonomous vehicle is a big challenge, and some great work is going on in the UK to progress the agenda.

Minister for Universities and Science, David Willetts has identified autonomous systems and robotics as one of the great eight technology challenges of the future. Professor Blythe specified the challenge as, bringing together disparate skills to unite the best possible systems. This is where the IET can play a key role.

Professor Blythe outlines the key challenges



Professor Phil Blythe presents keynote speech at the dinner debate

Future predictions

A key opportunity is to look at the resources we have in the UK and where funding is needed to take that quantum leap forward that will bring some of these products to reality. Professor Blythe stated that he can see autonomous vehicles of one form or another appearing in the not too distant future.

He also felt it important to distinguish between completely autonomous vehicles and those that allowed some degree of driver intervention. Dual mode systems are likely to operate for the next 10 years until people learn to trust the technology. Research could focus on sensor capabilities that can process information in real time, adjusting to varying environmental parameters. Ensuring reliable communications is vital, as well as robust cyber protection.

Taking autonomous cars as an example, congested cities might better optimise their road networks by eliminating the role of the driver, so they could control speeds and lane discipline and achieve steady flow. Lowering emissions in highly urbanised areas and lowering fuel bills would be attractive to many. Legal culpability will be a consequential concern. In which environments could these multidisciplinary technologies be tested most safely to aide clarity on liability?

Mobility and efficiencies

The average annual premium of a 17-18 year old driver is £1,853 according to the Association of British Insurers¹. Rising motoring costs are pricing young adults out of the car ownership market, however future autonomous vehicles could mitigate the risks for them to be 'drivers', reassuring the insurance market and parents. Similarly, road traffic collisions account for around 15% of deaths for young adults aged between 15 and 25 (DVLA, 2014 figures)². What percent decrease could be achieved for this age group if mass use of autonomous vehicles is realised?

DVLA figures also record that nearly 4 million people holding a current driving licence are aged 70 or over³. Autonomous Vehicles can bring holistic benefits to the health and well-being of our ageing population in remaining independent for longer. Ongoing research is being conducted by the University of Newcastle through the DriveLab project⁴. This project has an overall objective of increasing mobility by keeping elderly drivers on the road, with the aim of boosting an individual's independence and keeping them socially connected. People with disabilities and other non-drivers would also clearly benefit from the freedom to travel independently.

Time

Professor Blythe stated that there is an argument that autonomous vehicles would reduce the cost of congestion. Not the volume of the cars, but if you are not driving your car, you can do something useful instead, reducing the real costs. He cited an example in Seoul, South Korea where commuters set off for work some mornings knowing they are not going to arrive. They make it halfway, realise the traffic is too bad and then turn around. They have to be in their car, because it is a very important status symbol.



Bombardier presents first OMNEO train to the vice presidents for transportation of various French regions

Fuel

An autonomous vehicle, whether car, plane, train or ship can reduce fuel bills quite significantly. The human factor is removed from making the many decisions we are used to, making journeys smoother and increasing capacity – that is quite compelling. Platooning/road-trains reduce the need for large gaps between vehicles increasing efficiencies in fuel and road usage.

Professor Blythe set out the UK's newest research in developing driverless pods for urban areas. These are likely to be fuel cell or electric, to reduce CO2 emissions within cities – but with an added consequence of improving air quality. It is estimated that 50,000 deaths per year can be attributed to traffic pollution in urban areas. If it is possible to mitigate that through the combination of electro-mobility autonomy - that would be a fantastic game changer.

Failure

Looking at the technical challenges, the biggest is to use sensors to interpret and understand surroundings, so the vehicle knows how to go forward, fly, go under water, move through a signal, etc.

That is where the research needs to be focused to ensure the computing capabilities can process that in real time, determine what is happening out here and make the right decisions. If the sensors fail, is there a gradual degradation or redundancy? How do we ensure that those systems still run? Will they even know that something is going wrong?

The environmental parameters of different weather, terrain, flying or water conditions are all challenges for sensors. How they will detect their own failure is very important.

Some of the early systems that are reliant on remote communications for navigation and control had issues switching between communications providers. Ensuring they are guaranteed, secure and reliable communications to stay in contact is very important, as is cyber security, viruses and hacking. Reassurance that issues can be easily rectified and are ad hoc, as opposed to the norm, will allow the general public and transport operators to trust autonomous systems.

Society and perception

Changing the mind-set of a nation is difficult, but can be done gradually. People readily accept autopilot on aeroplanes and are gradually accepting similar on trains, but it could take a long time to accept it in other modes and this should be recognised. In cars, what people do not realise is that virtually every piece of technology, except the brain that pulls all this technology together, already exists.

Stay in lane, radar for the front headway and at the sides to check it is safe to move, intelligent airbags and head up displays all exist in one form or another; but are put together as a system of system. It is here that Government with industry and academia can work to bring together the technology in a user-friendly form.

Responses from debate

What follows are the key questions asked of the attending guests and the responses given. In particular what role the IET could play in moving the autonomous vehicle agenda forward.

What are the real drivers for change; who will benefit and what differences to daily lives will highly automated vehicles and systems make?

Here, guests used the road vehicle as a basis for discussion as they felt that this area would require significant changes. Increased road safety and fuel efficiencies were seen as high priorities for driving forward the autonomous road vehicles agenda.

Important factors such as introducing standards for the system architecture and clear legislation on responsibility levels needed developing now and there were lengthy discussion on the pros and cons of who should lead on developing standards: Government, manufacturers, insurers or the Highways Agency? It

was also recognised that in a technology-led market developing new legislation that can keep up was seen as a real dilemma for all stakeholders. In agreeing that a step-change approach was needed for autonomous road vehicles, guests debated the key benefits to society which included;

- ageing population: maintaining independence
- impaired or disabled drivers: greater freedom of mobility
- fuel: better efficiency gains, reduced congestion and emissions, potential to reduce independence on fossil fuels

It was felt that the IET had a role in bringing people together from different areas: transport, built environment, communications and aerospace to find real solutions to drive forward change. As a multidisciplinary organisation, the IET can create a platform for the system architecture: roads, cars, monitor, control and command and cyber security to be orchestrated impartially.



Guests at the thought leadership dinner debate



Bombardier presents first Regio 2N train - interior view

Government have recently set aside £35 million to propel the UK to future growth in robotics and autonomous systems through centres of excellence. But what will be the net gain for the public, industry and UK plc?

Guests agreed that a net gain was a clear and absolute definition at Government level on autonomous vehicles classification and allocation (mission =autonomy or tasks = robotics). There could be varying degrees of sophistication for the variety of transport modes that, once defined, could be used by all stakeholders.

It was agreed that the UK has niches of expertise, but breadth remained unclear. There was a clear consensus that the diversity of SMEs in the UK are where autonomy development can flourish and provide benefit to UK plc. Additionally, experts considered what the UK's real game-changer is. Is it in

- providing a regulatory framework;
- developing legislation;
- or in training and education?

Again, it was felt that the role of IET lay in steering discussions and debates i.e. underwriters, standards, codes of practice in developing robust solutions for the many challenges to implementation.

There is a lack of cross-sector working in R&D, application of technology and human factors – what incentives should be provided to individual transport modes so they see themselves as part of a total transport system and work together more?

Guests explored, with difficulty, what incentives should be provided to individual transport modes so that they see themselves as part of a total transport system working together.

They agreed that the public transport area is where the Government has a role to make the market framework correct, it was easy to see where things might be incompatible e.g. rail industry franchising arrangements.

However, they could see a role around the market structure of railways. It was difficult to see how that same market opportunity could be achieved in the highways.

Debaters felt it was more a question of leverage. In the context of the transition phase for autonomous vehicles, for example, would there be dedicated lanes on motorways? Would there be better insurance rates for those using autonomous vehicles? Is the automotive industry prepared to invest in underwriting insurance?

Implementing incentives to use autonomous vehicles may help increase adoption in the longer term.

Guests agreed that being a champion of autonomous vehicles was both valuable and useful for the IET to do. The IET has a role in putting the UK on the map with autonomous vehicles.

The IET could play a very strong role in helping the public to understand how safety can be developed and demonstrated for autonomous vehicles. For example, there are robotics in the home already - the Dyson robotic vacuum cleaner. If people can be shown, through simple means that autonomy works, they would be more likely to accept it in bigger ways, such as their vehicle.

What are the unintended consequences of highly automated vehicles and systems? What should engineering and technology professionals be aware of when developing new or existing technologies?

For this question attendees focused on the societal impacts for driverless cars. Through discussions they explored the fact people enjoy driving - so would there be a backlash to driverless cars being forced upon us? How do you convince people to adopt this technology?

The issues of de-skilling and driver training were also discussed at length and how the UK would need to adapt driving tests and training. What would happen if people became too used to these autonomous vehicles? They would become less skilled, but need to over-ride the system if things go wrong. How can we train for that?

Increased mobility may be intended, but could equally be an unintended consequence, which could lead to increased congestion, because the percentage of older people and previous non-drivers using road vehicles would increase.

In terms of the automotive industry itself, they would have issues with marketing cars, as there would no longer be a driving experience. How could they convey the benefits? There are issues of different cultural perspectives to driverless cars around the world.

A good debate was had around the scenario of mixed traffic; manually driven and autonomous cars. A particular point raised was that, in previous driver simulations undertaken, drivers of manual cars typically mimic driverless cars and would start driving two metres behind the car in front, which could be dangerous. So solutions for how mixed modes are integrated need fuller development.

There are possible unintended consequences for air and rail travel demand, if car transport becomes much easier. There may be different ownership and business models, with cars sold and owned in a different way, which could have impacts on the insurance industry. There was quite a bit of debate as to whether the insurance industry would even be needed and how they would make their money.

The IET could play a role in hosting public debates, with rational discussion about the benefits and the risks to raise awareness. Bringing together different bodies, such as the technology and insurance industries, which would not necessarily come together, was also seen as a key role for the institution. It could provide a global perspective and international standards, with accreditation to ensure that future engineers are trained in these wider societal and ethical factors.

There was some discussion about the increasing importance of human factors, which need to have a much bigger role in the development of autonomous vehicles.



What are the main societal impacts of autonomous vehicles? Are they positive or negative?

Societal Impact	Positive or Negative	Reason
Car Insurance	Negative – insurance companies Positive – insurance buyers	Depends on autonomous vehicle model, but if franchised as per railways and cars are no longer individually owned, or just leased, requirement for personal insurance will decrease.
Safety	Positive - increase in safety	Overall safety should improve – public expect a greater level of safety when they are not in direct control, also removes human from control function.
Reliability	Positive	If a franchise/fleet scenario then overall reliability should also improve through more regular servicing.
Mobility	Positive	Autonomous cars in particular may allow better mobility for older people, disabled and young adults.
Usage	Positive – other modes Negative - roads	There may be a significant increase in journeys if autonomous road vehicles are available. May relieve pressure on other modes of transport.
Car industry	Negative	Less cars may need to be produced due to reduced desire for “latest model”
Reduced urban sprawl	Positive	Autonomous road vehicles may reduce the need for people to live in town centres and could facilitate a return to the countryside.
No differentiation in cargo	Positive	Self-loading freight and freight can be treated in the same way.
Taxi companies	Negative - for taxi companies Positive – for other drivers on the road	With autonomous vehicles (in the extreme case e.g. extension of ULTra at T5) may mean in the long term a significant reduction in the number or taxi companies required.

A key objective of the evening was to look at the commonalities between the various industries – aerospace, automotive, marine and rail – and sharing knowledge. It is not for the IET to reinvent the wheel or the autopilot for each industry, so sharing knowledge is very important and would also reduce R&D costs.

How people interact and behave when with autonomous vehicles, whether aircraft or road is key for engineers to understand the IET can facilitate that type of discussion and debate.

Exploring the human factors involved in the applications of technology is another key area in how the IET can help to develop solutions.

What do you think are the next steps for autonomous vehicles in say 5, 10, 15 years' time? Who should be involved?

Guests talked at length about standards and importance of having a common framework that allows OEMs to develop products whilst not stifling innovation and restricting opportunities for progress.

The UK can lead in this area as we have a long history of leading navigators. UK Formula One teams are seen as a demonstration of the UK leading in highly advanced technologies. Debaters felt strongly that assisted driving was less threatening than fully autonomous driving but, for the older and less able drivers, the system has to work. Imagine the scenario; if an autonomous road vehicle brings the passenger 300 metres from their destination and then stops, they might as well have not started the journey.

5 years ahead

It was acknowledged that many of the vehicles that will be around in five years have already been designed. There is not a lot that can be done to change them. They will be sold based on the systems' user benefits. Autonomous road vehicle developments will exist in closed systems, like the Lux Network and PRT systems, which will be effective.

10 years ahead

Looking further ahead, it was thought that a convergence between those closed systems becoming more open and existing road vehicles was definitely possible with infrastructure becoming more sophisticated and managing more autonomy.

15 years ahead

There needs to be much more discussion and acceptance that autonomous vehicles will have collisions – at some point. They will have a different type of collision, but for the one error made by an autonomous vehicle, they will have made 10,000 more correct errors than a human driver.

Seatbelts are a key example: there are situations where they can make injuries worse, but overall they make driving much safer.

Having a forensic record of what happens in collisions is useful, but there are privacy issues around that.

A real transformational change seen by guests was national broadband coverage across the UK; applicable to cars but also to anything being moved.

Rio Tinto, the mining company, spends more money on autonomy research than any other research council. What can be learnt and utilised from that substantial research pool?

A future vision of what might a car manufacturer look like in 15 years' time was explored. It might be a small Swedish company 3D printing its vehicles in China and running code that has been written in the UK.

The UK target should be to have dominance in the core technologies, the derivation of the fundamental principles (safety and operational) to be applied, the code and information structure on which automation depends, and from which the global industry derives benefit. The IET can play a role, firstly in drawing on the history and experience of members in areas like GSM, to avoid any pitfalls, but also use their diverse contacts and representation across industries to ensure that that domination is enduring.



Summary

There was a consensus among attendees that, because autonomous systems involve many disciplines, manufacturers and nations, a system of systems approach is necessary to connect them all together.

You need some person or body to be the system architect, who decides what is acceptable and what the rules are. This is not just a UK issue, as cars are made differently in Europe, America and Japan. Who would be the system architect? Is it a regulator in some form or perhaps a design authority? Is it Government, the Highways Agency or a joint venture of manufacturers? All that needs to be considered and a framework agreed.

In all of this, we need to be agile. As already highlighted, technology moves incredibly fast. Regulation and legislation are running to catch up, but they never can. We need to be more agile or we may waste opportunities for efficiency. There is a bit more to consider about the system of systems approach and the architecture approach, which of course the IET is well placed to facilitate.

One of the conclusions that might be drawn is the importance of this debate being around the benefits this will bring to society, individual users and groups within society, such as the elderly or less able. Talking in the language of engineering and using this scary word 'autonomous' might detract from focusing on the benefits that we all might enjoy.

Talking about 'assisted driving', rather than 'autonomous' may be a less scary concept and is accepted in the context of 'assisted living' in the healthcare sector. As engineers, we need to use the right language if we want to have a meaningful debate with society and other stakeholders.

Conclusion

It is clear that there are number of common threads. Much of the debate centred on road vehicles, or the car, which reflects that transport area as being one of the most challenging environments to move to full autonomy.

Attendees of the debate expressed high levels of confidence that autonomous vehicles would become more pervasive. The challenge was more in full autonomy in mixed traffic environments, as opposed to closed or semi closed environments, where there was less interaction with the wider public. Until mixed mode technologies could be widely tested, talking about 'assisted' rather than 'autonomous driving' might help the public get used to driverless vehicles on the roads.

The UK has also been successful in developing standards that could provide a framework for innovation and a platform by which small and large companies could add value, particularly in software related technologies.

The IET could play an important role in bringing together all the stakeholders who might benefit from the effective deployment of technologies in this space, so that ideas could be compiled and reported to Government.

Autonomous cars are a reality, they exist (within permitted environments) and they work. There is an opportunity to realise the benefits of these cars to benefit the whole of society. They will make driving more accessible, safer, convenient and less reliant on fossil fuels. What's not to like?

There are many hurdles relating to liability, regulation and not least the massive economic powerhouses that automotive manufacturers are. There is also the human factor to consider: people love to drive their cars, it holds a special place in our psyche from childhood to adulthood. For most people being able to drive and own a car is a rite of passage and any realistic implementation models for autonomous cars is likely to want to change that. So, will there really be a fully autonomous future?