ROBOTS ON WHEELS

Talk for Harpenden Village Rotary Club about the Laws of Driverless Cars

Wednesday, 18 April 2018

Introduction

Thank you very much for inviting me to speak to you this evening. It is lovely to be invited back to my home town and a great privilege to speak to Rotary about driverless cars, intelligent robots and the laws that might govern them.

Rotary describes itself as "*a global network of neighbours, friends, leaders, and problem-solvers*"[1].

Well, this subject raises questions for all of those people.

The Today programme on Radio 4 this morning featured Bill Gates, who was asked about large companies' commercial use of private data. And then the government minister responsible for digital technology spoke about cyber security of NHS Trusts and other public bodies, in response to threats of cyberattacks by Russia. So data security and robots are on our minds.

I will use the phrase driverless cars, but that's a rather overcomplicated term, with echoes of "*horseless carriage*", one of the first terms for a modern car. Bear in mind that the vehicles we're discussing might do more than just take you from A to B. Like your smartphones, their original function might be the least of their features. So I would bet that we end up with a shorter term ("BotCar", maybe?), but I'll leave that to your imagination.

Robots on Wheels

When I was at school, I had a lever-arch file covered in cartoons cut out of my Dad's copies of Punch magazine. My favourite showed a group of Daleks at the bottom of a flight of stairs; their leader says, disconsolately, "*Well, there goes our plan to conquer the universe*"[2].

Robots on wheels have come a long way since then:

[1] https://www.rotary.org/en
[2] Or words to that effect.

That is Handle, one of the robots built by the American company Boston Dynamics[3]. They describe Handle as:

> "*a research robot that stands 6 and a half feet tall, travels at 9 miles per hour and jumps 4 feet vertically. … Wheels are efficient on flat surfaces while legs can go almost anywhere: by combining wheels and legs Handle can have the best of both worlds*"

And this is Handle coming down stairs:

[3] See the film at https://www.bostondynamics.com/handle

Handle is the descendant of robots built by American universities, in competitions run by the United States' Defense Advanced Research Projects Agency (DARPA). One of those competitions was to design a rescue robot for sites too dangerous for human rescuers. Another was to design a driverless car.

I've started with robots both because that would be one way to describe a driverless car, but also to illustrate how far the technology has come. In the first DARPA robot competitions, many of Handle's predecessors were heavy, poorly-balanced bipeds, prone to falling. In the driverless car competitions, the first autonomous vehicles would, if they started at all, grind to a halt within very short distances.

The technologies driving autonomous vehicles have come far. The key technology is a form of Artificial Intelligence known as "machine learning" or "deep neural learning".

AlphaGo

"Go" is a complex, chess-like game played throughout China, Korea and Japan. Moves at the highest level of play are described as being intuitive. Between 2015 and 2017 Artificial Intelligence, in the form of the AlphaGo computer developed by British computer scientist Dr Demis Hassabis and the team at DeepMind, won all three of its competitions against the top human players in the World[4] (to the right of the photo is Lee Sedol, the Korean world number 5, being beaten by AlphaGo in 2016).

And the rise of AI continues. Artificially intelligent systems are being used to trade on stock markets and by insurers to assess risks. Artificially intelligent weapons systems are in development[5].

The combination of commercial and state interest is driving innovation. Fully driverless cars are a real prospect. Many of the technologies that will allow driverless cars to navigate - GPS, street mapping and 3-dimensional street view imaging – are in place. Once fully driverless car technology has been developed, it should bring many benefits – not least improvements in road safety and greater mobility for those presently unable to drive themselves.

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[4] Culminating in the matches against World Champion Ke Jie in Wuzhen, China, in May 2017: http://events.google.com/alphago2017/

[5] https://www.politico.eu/article/opinion-europes-ai-delusion/

But these technologies are unfamiliar. They bring dangers as well as benefits, as several accidents involving partially autonomous cars in America have shown. Every day brings a headline about robots, Artificial Intelligence and driverless cars. The headlines always go to the extremes – technology is either the saviour or the grim reaper. The prospect of General Artificial Intelligence – of entirely autonomous robots – is typically described in apocalyptic terms.

Something old, something new?

A world of semi-independent robots would be a change. But would it be entirely outside our experience?

As a barrister, I travel all over the country. A few weeks ago I had a case in Bristol, where I had been at University.

Bristol is a city of engineering glories – especially those of Isambard Kingdom Brunel. The Clifton suspension bridge designed by Brunel in 1829 spans the Avon Gorge (and ought not, I have heard it said, be able to support the weight of the modern traffic that it does support). Temple Meads is Brunel's station (the terminus of the Great Western Railway, of which he was appointed chief engineer at 27 years old, in 1833). The S.S. Great Britain – the iron steamship launched in 1843 – now sits again in Bristol docks, after her rescue from decrepitude in the Falkland Islands in 1970.

One of the pleasures of rail travel is that there is occasionally time to catch up with some reading. On the journey back from Bristol I was reading a biography of Elon Musk[6], a great present-day innovator in transport.

My journey back to Bristol reminded me of the fear that mere travel at the speeds involved in early railways would cause immediate, mortal injury. The website of the museum of the S.S. Great Britain has this headline about the iron steamship, with its innovative screw propeller technology: "*When she was launched in 1843, she was called "the greatest experiment in creation*"[7].

So present emerging technology is not the most startling event.

And there are striking similarities between the individuals involved, Brunel and Musk: both from families of engineers, both extraordinarily driven innovators and businesspeople, neither intimidated by the demands of expense or distance. Just as Brunel built railways to the edge of the land, then steamships to travel the oceans beyond, so Elon Musk builds electric cars, rockets

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[6] "Elon Musk" by Ashlee Vance (Virgin Books, 2nd edn, 2016)

[7] http://www.ssgreatbritain.org/story/timeline

and space capsules. Elon Musk wants his cars to be able to drive themselves, on electric power, for greater and greater distances; then he wants to create the vehicles to take humanity to Mars.

Robot cars and rockets to Mars: those apparently unlikely things - like rapid, transoceanic steamship travel in the mid nineteenth century - now seem likely to happen.

Sadly, I cannot tell you very much about rockets and going to Mars. Not being an engineer, I cannot tell you anything mechanically useful about the workings of an electric car.

I can give some views on what happens when sophisticated machines – particularly cars and other motor vehicles – go wrong and cause injury. Because, sadly, that happens far too often.

In my working life I spend a lot of time advising and representing people who have been injured in accidents involving machinery – especially road vehicles.

I advise the injured, drivers whose actions or omissions have caused such injuries, and the families and others (both people and businesses) who are affected by those accidents. It is a long list of injury and damage. Its root is often human error, without any malign intent, in the tiniest of moments.

2016 Road Traffic Accident Casualty Figures

(Source: UK Department of Transport[8])

24,101 seriously injured

1,792 fatalities

181,384 total casualties

My view is that that list of damage can be reduced – probably to a very great degree – by the developing technology of autonomous vehicles.

That technology is developing at a very fast pace. And the first mass producers of safe driverless technology will receive huge financial rewards.

Any system of transport requires laws, and new systems require new laws. That was true for the railways. It was true for motor vehicles. It will be true for driverless vehicles. The process of regulation has started[9].

[8] https://www.gov.uk/government/statistics/reported-road-casualties-great-britain-annual-report-2016

[9] Eg. by the Automated and Electric Vehicles Bill, now at Committee stage in the House of Lords, described (at https://publications.parliament.uk/pa/bills/lbill/2017-2019/0082/18082en02.htm) as a Bill "*intended to enable consumers in the United Kingdom to benefit from improvements in transport technology. The Bill makes provision for (1) the creation of*

The challenge will be to think about and design laws *ready* for the technology. Because there are a lot of public interests at stake. I'll turn to those public interests, and the need for laws to serve them, now.

Making Good Laws

There is not time to deal with every aspect of the law. The laws of employment and environmental protection, for example, are likely to alter profoundly over time, in response to new vehicles and intelligent robots.

So I will focus on the two areas most in the news now – safety and data – and on a third area which particularly interests me – roads. In all of those areas we can draw upon past solutions.

Safety

The need to set laws to protect humans from machines is not new: all new technology has led to social change. The Railway Acts, Factories Acts and Road Traffic Acts were all responses to safety concerns arising from new technologies.

The mass manufacture and sale of consumer goods led to laws providing for product liability.

The railways also led to new laws of contract (for example in relation to notice of contractual terms – something which smartphone technology reminds us of every time software is updated and we are asked to "*Agree or Decline*" to accept new terms).

So we might take the lesson of history to be: "*Don't worry, sit back and the law will develop as things progress*".

That is one approach. And it has generally been the legal approach not to find someone at fault on the basis of knowledge that they could not reasonably have had at the time of an accident.

But there are powerful arguments in the other direction: that protective laws after the event come at the cost of much suffering beforehand, and that we should prepare ourselves a little better than that.

a new liability scheme for insurers in relation to automated vehicles, and (2) the creation of regulations relating to the installation and operation of charging points for electric vehicles. The Bill also sets out the regulatory framework to enable new transport technology to be invented, designed, made and used in the United Kingdom".

In the first place, there has been an underestimation of how close to fully automated driving we are.

The commercial evidence alone shows that major players are putting more and more resources into autonomous cars. For example, last week BMW announced the opening of its autonomous driving campus near Munich, in BMW's words: "*a forward-looking development facility that showcases the BMW Group's transformation into a tech company*"[10].

And the engineering of autonomous vehicles is now part of university courses. For example, Stanford University recently posted film of the final demonstration of students in the class "*Principles of Robotic Autonomy*"[11]

So those are positives: the technology is at a more advanced stage than you might think.

The negative reasons for preparing our laws early on include a point in the news again this morning: Cybercrime.

I have written and lectured about cyberattacks on autonomous vehicles and the challenges that this presents to law enforcement and others looking to prevent fraud or malicious attacks. I will not go into the detail of that for reasons of time, but the essential points are that:

- First, technology does not create crime but increases the means for it
- Second, greater technology in vehicles leads to more "attack surfaces", as they have been called, and requires security by design (as several manufacturers have already recognised,)
- Third, technology alone will not provide the means to defeat cybercrime. Detection, investigation and enforcement through the courts are likely to remain human activities both on practical and ethical grounds
- Fourth, police and the courts need to be trained and resourced to understand and fight car cybercrime (and, as the Senate interview of Mark Zuckerberg last week showed, some legislators responsible for these areas might not be sufficiently prepared).

The question of safety also arises in relation to road collisions.

We are not yet at full automation of vehicles. The scale of automation – from human driver to fully driverless – is provided by the Society of Automotive Engineers' (SAE) standard:

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[10] 11 April 2018: https://www.bmwgroup.com/en/company/news.html
[11] 10 April 2018: https://news.stanford.edu/2018/04/10/autonomous-robotics-class-integrates-theory-practice/

SUMMARY OF SAE INTERNATIONAL'S LEVELS OF DRIVING AUTOMATION FOR ON-ROAD VEHICLES

Issued January 2014, **SAE international's J3016** provides a common taxonomy and definitions for automated driving in order to simplify communication and facilitate collaboration within technical and policy domains. It defines more than a **dozen key terms**, including those italicized below, and provides **full descriptions and examples** for each level.

The report's **six levels of driving automation** span from *no automation* to *full automation*. A **key distinction** is between level 2, where the *human driver* performs part of the *dynamic driving task*, and level 3, where the *automated driving system* performs the entire *dynamic driving task*.

These levels are **descriptive** rather than normative and **technical** rather than legal. They imply **no particular order** of market introduction. Elements indicate **minimum** rather than maximum system capabilities for each level. A particular vehicle may have multiple driving automation features such that it could operate at **different levels** depending upon the feature(s) that are engaged.

System refers to the driver assistance system, combination of driver assistance systems, or *automated driving system*. **Excluded** are **warning and momentary intervention systems**, which do not automate any part of the *dynamic driving task* on a sustained basis and therefore do not change the *human driver's* role in performing the *dynamic driving* task.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Key definitions in J3016 include (among others):

Dynamic driving task includes the operational (steering, braking, accelerating, monitoring the vehicle and roadway) and tactical (responding to events, determining when to change lanes, turn, use signals, etc.) aspects of the driving task, but not the strategic (determining destinations and waypoints) aspect of the driving task.

Driving mode is a type of driving scenario with characteristic *dynamic driving task* requirements (e.g., expressway merging, high speed cruising, low speed traffic jam, closed-campus operations, etc.).

Request to intervene is notification by the *automated driving system* to a *human driver* that s/he should promptly begin or resume performance of the *dynamic driving task*.

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The current state of play is that:

- Mass-produced car technology is now (so far as we know) capable of level 2
- some manufacturers intend to release level 3 cars for sale soon, on various estimated timelines; and
- some manufacturers have stated that they will bypass level 3 (which they consider a less attractive technology) and manufacture level 4 cars first.

Safety expectations differ. It seems unlikely that any technology (in any imaginable field) could achieve perfect safety, so that is unlikely to be the standard. The "trolley question" or "death switch" thought experiment (which is premised upon an inhumane choice of having to inflict injury upon someone) seems to belong in that sort of absolute category. An approach which has some force is that an autonomous vehicle should be at least as safe (and preferably safer) than a human driver. How to evidence that standard is another question entirely.

Roads

No topic illustrates more immediately the difficulty of introducing a new road transport technology than the shape of the roads themselves. Many of our roads are built on ancient foundations. The roads of many towns and cities (I think of the City of London, for example) are too narrow and winding even for two-way vehicle traffic. All vehicle technology must adapt to that.

It must also adapt to the presence of other, non-artificial vehicles, objects, people and animals. The roads will always be used by people, by bicycles, by other vehicles and by animals (from dogs and cats to horses and livestock). And, for a good while, autonomous vehicles will share the roads with vehicles still driven by humans.

How will the law accommodate all those differences? Well, the answer is that it has done so to date and continues to transform to do so (see, for example, the current debate about the further extension of road traffic offences and the obligation to insure to cyclists).

One approach is to look at the physical features of roads. For example, my cycle route to work across London features roads, two parks, a bridge then a stretch of cycle lanes, some of which are physically separated by design from other traffic. The bridge part of the route has extra separation of the cycle path and pavements from the highway, because of barriers installed after the terrorist attacks on two London bridges last year.

The separation of road users by road design has had unexpected benefits: in particular, the part of the cycle superhighway that is separated from the road by a high kerb and paving creates a road shape that artificial systems (including cameras, radar and networked vehicles) will probably find easier to navigate than a conventional road. The higher barrier introduced to prevent terror attacks provides an even clearer division. So separating road users for other reasons might also be good preparation for new technology.

Data, privacy and individual rights

Perhaps the most striking of the developments in driverless technology is the growth of "machine learning" – a type of artificial intelligence that *learns*. Networked cars will be able to gather, use and store information.

They will talk to each other. Their conversations and conclusions will be sent to databases. The commercial value of that data will be considerable.

Challenges to the use of that data by those harvesting it – whether by operating the system legitimately or by hacking into any part of it criminally - are bound to arise.

So data security and privacy might be the new battlegrounds of risk, where law and insurance might even find themselves most often engaged.

The recent controversy about Facebook only serves to accentuate the importance of data security and of the new Data Protection Bill about to become law.

It should also focus our minds on the useful laws that we already have. The Human Rights Act 1998 – incorporating the European Convention on Human Rights into British law and unaffected by the Brexit referendum – was written decades before smartphone technology emerged. It-provides a right of privacy. In the age of big data, that law looks especially important. And the word "Human" in "Human Rights" takes on an added feature: human as distinct from robot.

Conclusion

There is too much in this subject to cover in 40 minutes. A question that I've not mentioned, but with which I will leave you, is this:

Who owns all this stuff?

At the beginning of this talk I mentioned 3 particular examples in the area of robot technology: Street mapping, Boston Dynamics' robots and the DeepMind computer which defeated leading human players of Go.

All three of those have been owned by a single company – arguably the World's most powerful company, Google[12]. Google even owns the company that shows us these technologies: YouTube.

We have been here before. For example: it was Theodore Roosevelt who, as 26th President of the United States, surprised and annoyed many of his supporters by opposing an emerging monopoly among the railway companies. He saw transcontinental transport as being key to the social and economic interests of the U.S. in the 1900's, and monopolies as likely to stifle innovation and development. He instructed an Attorney General to go the Supreme Court to make that point, against fierce and powerful commercial opposition. And he won. Theodore Roosevelt's preservation of competition in early twentieth century transport has, I think, lessons for us in the early twenty-first century.

So, we can be confident that we have faced similar questions before. We don't need to be afraid or be driven to either unreal extreme: of total subjection or of utter resistance to technology.

In short, if we all join in the innovation, and make our voices heard, we will get the best out of it. We can start by looking around and asking how things work now.

Thank you for listening.

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[12] Google is reported to have sold Boston Dynamics in June 2017, having reportedly acquired it in December 2013.