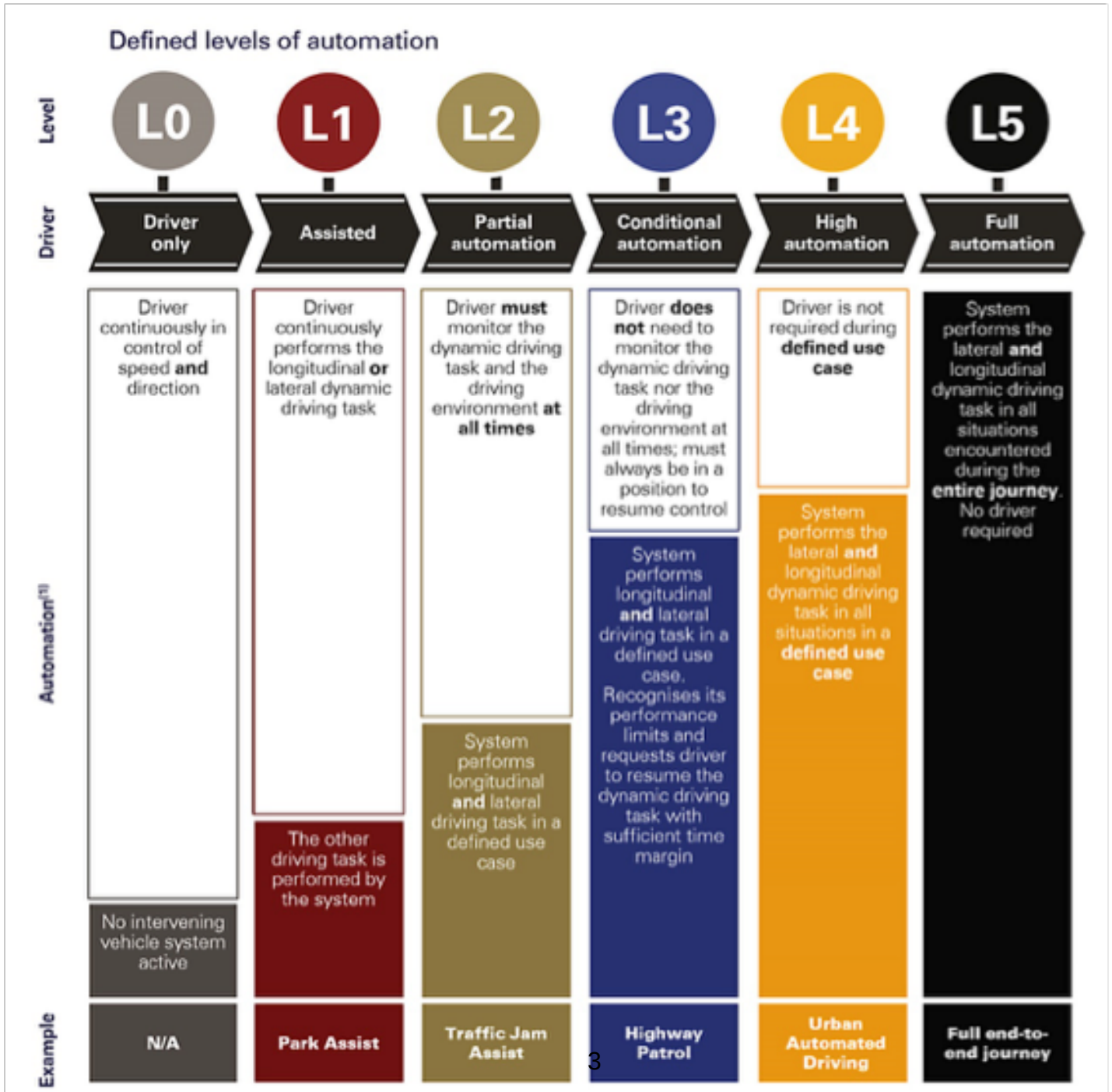
Is Society Ready for Driverless Cars?

Martyn Thomas CBE FREng
IT Livery Company Professor of Information Technology

Topics

- Levels of Automation
- Plans and Timescales
- The Social Benefits that Driverless Cars might bring
- The Social Problems that Driverless Cars might bring
- Safety: How Safe is Safe Enough?
- How Safe are Human Drivers on UK Roads?
- Technology related issues to be overcome
- Transition to Driverless Cars: should human drivers be banned?
- Conclusions


Defined levels of automation
Level
Driver
Automation[1]
Example
L0
L1
L2
L3
L4
L5
Driver only
Assisted
Partial automation
Conditional automation
High automation
Full automation
Driver continuously in control of speed and direction
Driver continuously performs the longitudinal or lateral dynamic driving task
Driver must monitor the dynamic driving task and the driving environment at all times
Driver does not need to monitor the dynamic driving task nor the driving environment at all times; must always be in a position to resume control
Driver is not required during defined use case
System performs the lateral and longitudinal dynamic driving task in all situations encountered during the entire journey. No driver required
No intervening vehicle system active
The other driving task is performed by the system
System performs longitudinal and lateral driving task in a defined use case
System performs longitudinal and lateral driving task in a defined use case. Recognises its performance limits and requests driver to resume the dynamic driving task with sufficient time margin
System performs the lateral and longitudinal dynamic driving task in all situations in a defined use case
N/A
Park Assist
Traffic Jam Assist
Highway Patrol
Urban Automated Driving
Full end-to-end journey

Some of the Companies

Plans and Timescales

Most companies' current plans seem to be for Level 3 or Level 4 cars to be available in 2019 – 2021, with Level 5 cars becoming available around 2025, although Tesla's CEO, Elon Musk has said he expects level 5 cars to be in production by 2019

Many Governments, including the UK, have made special provisions to encourage driverless car development.

The political and commercial pressures are irresistible despite the technical and social barriers to early and widespread adoption.

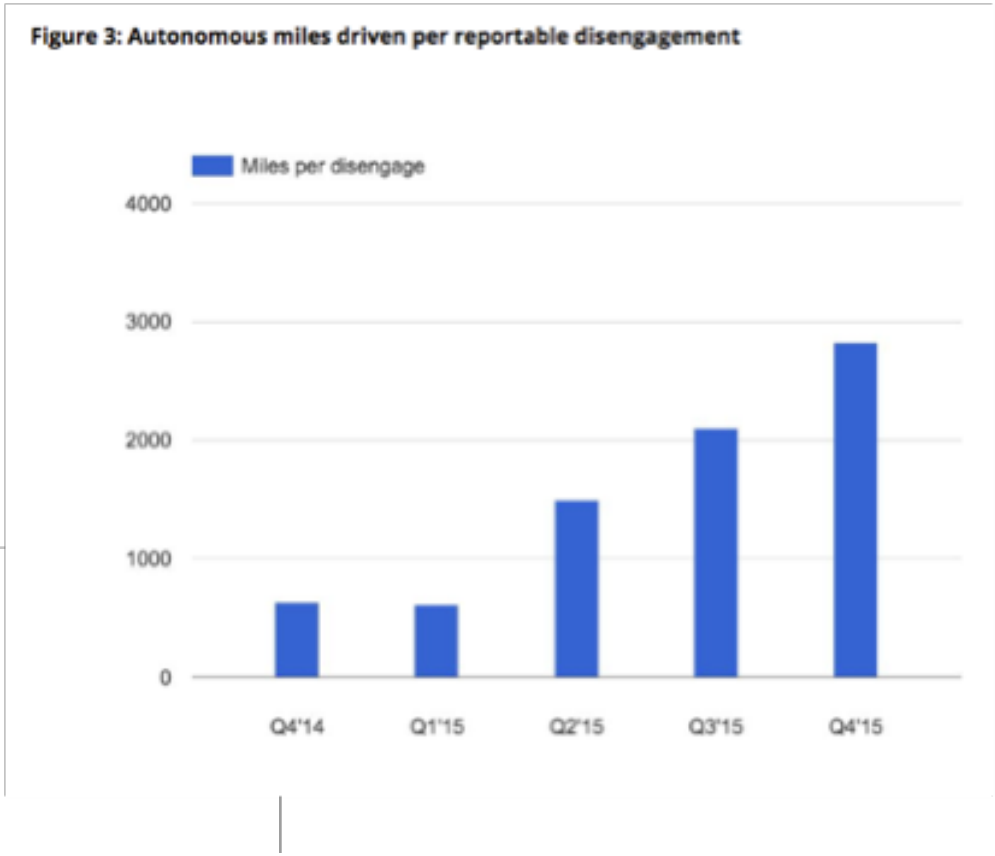
Progress in testing

By the end of November 2015 , Google had operated its self-driving cars in autonomous mode for more than 1.3 million miles.

Of those miles, 424,331 occurred on public roads in California -- with the vast majority on surface streets in the typical suburban city environment of Mountain View, CA and neighbouring communities.

Test driving currently needs a safety driver.

California requires that companies report when a manual intervention has been made. **This is how often they had to do so**.



The Social **Benefits** that driverless cars might bring

- **Safety: Fewer road deaths and injuries**
  - >1700 fatalities annually and many more serious injuries
  - A HoL Committee was told that between 75% and 95% of all road accidents are caused by human error
- **Better mobility for people who are unable or unwilling to drive**
  - This benefit needs Level 4 or 5 cars
- Red**uced congestion and better fuel economy.**
  - If cars co-operate to reduce congestion and accelerate and brake less often
- **More free time, both in the car and by making fewer journeys**
  - The average driver spends 335 hours driving every year – about 6 working weeks.
- **Economic benefits**
  - From designing/building the cars, cheaper transport, higher worker productivity

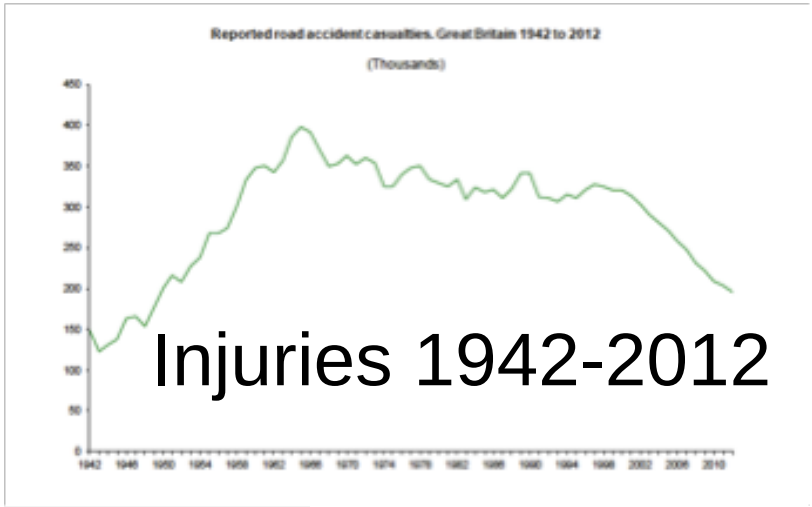
The Social **Problems** that driverless cars might bring

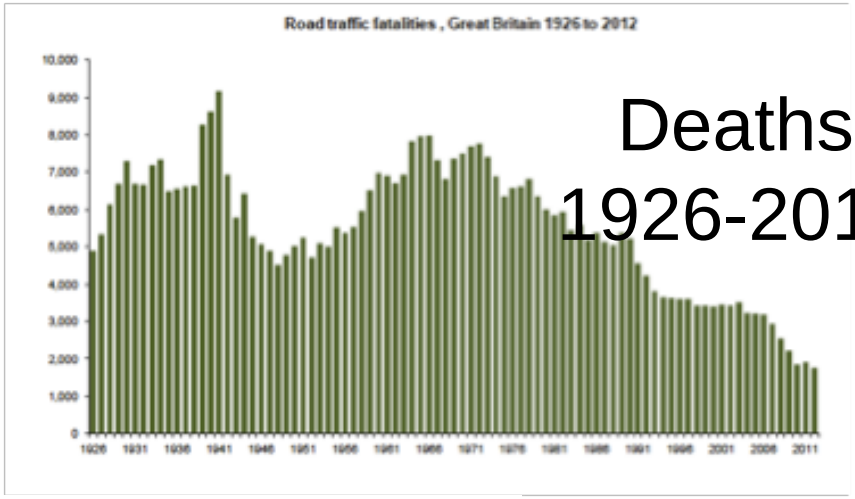
- Interactions with humans are not well understood
  - Will human drivers **bully** driverless cars? Will pedestrians take over the streets? How will an AV force its way into traffic? Might journey times become much longer? Would vulnerable passengers be safe in a car that anyone could stop?
- Might AVs be used as weapons? Or to assist crimes? Or roadblock protests?
- Increased congestion and fuel consumption?
  - There could be many more journeys by empty vehicles
- Economic problems?
  - In America alone, the Bureau of Labor Statistics says that in 2016 there were 1,704,520 Heavy Truck Drivers, 858,710 Light Truck or Delivery Service drivers, 188,860 taxi drivers and chauffeurs, and many other drivers, supervisors and others in related occupations.

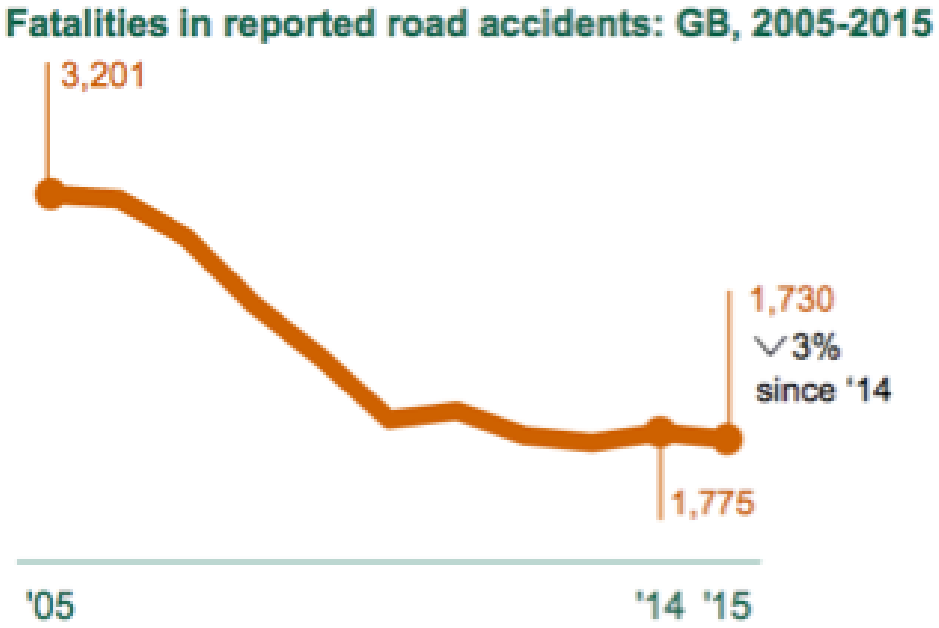
Safety

- How safe does a driverless car need to be, before it should be permitted on public roads?
- Should it be at least as safe as an average human driver? How confident should we be? How can we tell? How much evidence would we need?

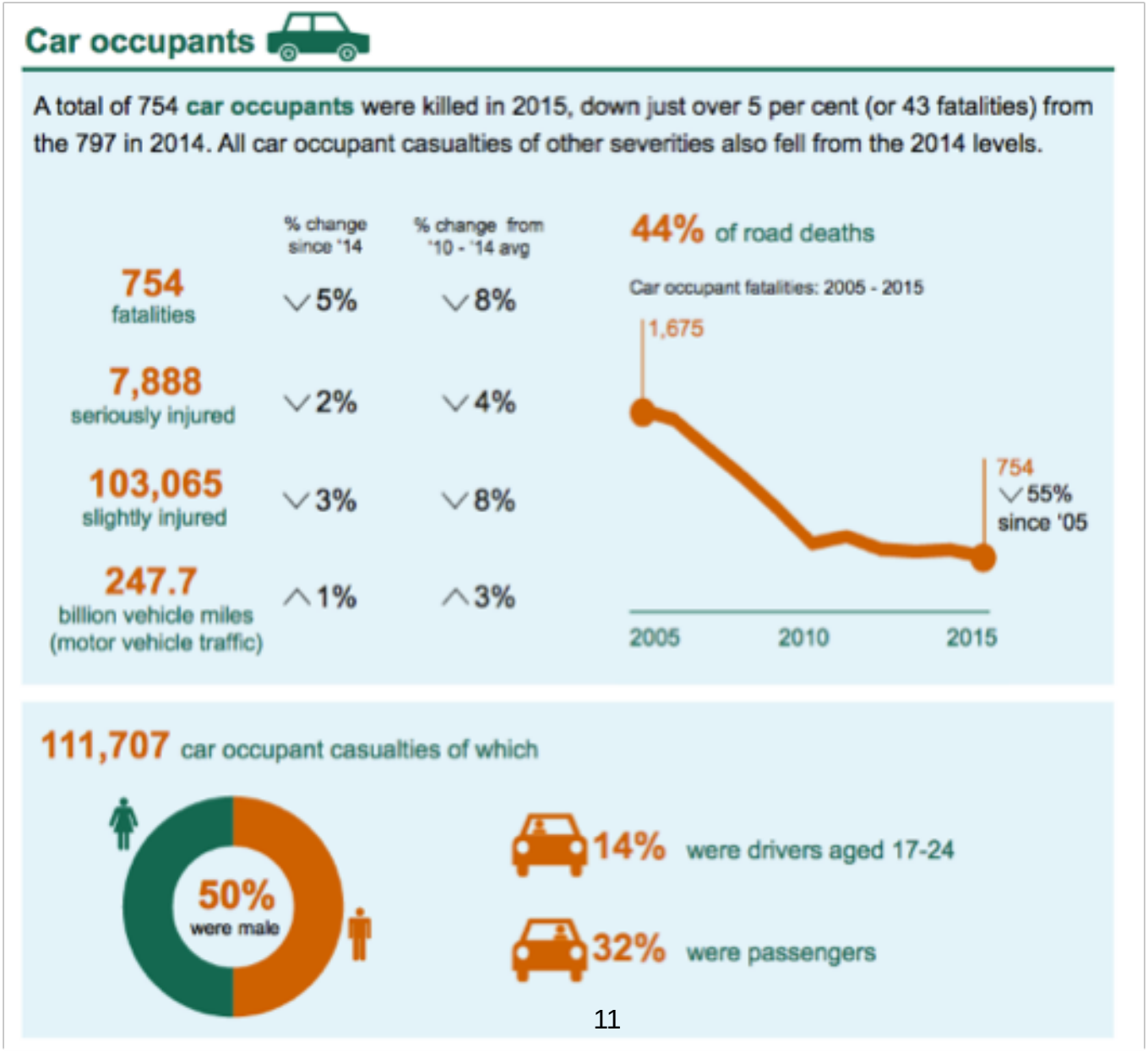
Human driven cars have become much safer







Human drivers have 2-3 fatal accidents per billion miles



How Much Testing is Needed?

To match a human driver fatality rate of 2 - 3 per billion miles

fully autonomous vehicles would have to be driven hundreds of millions of miles and sometimes hundreds of billions of miles to demonstrate their safety in terms of fatalities and injuries. Under even aggressive testing assumptions, existing fleets would take tens and sometimes hundreds of years to drive these miles — an impossible proposition if the aim is to demonstrate performance prior to releasing them for consumer use. **Our findings demonstrate that developers of this technology and third-party testers cannot simply drive their way to safety.**

Kalra, Nidhi and Susan Paddock. Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability?. Santa Monica, CA: RAND Corporation, 2016. https://www.rand.org/pubs/research_reports/RR1478.html.

Technical Issues

- CAV depend on software (>100 million lines …), telecoms (Bluetooth, 3G, radio …), radar, lidar, optics, AI (for object recognition and decision making), GPS, HD maps …
- All this needs to be **reliable** under all road and weather conditions, and **cybersecure**.
  - Some current L1 systems fail in snow, read road signs on side roads, and fail to track lanes in roadworks …
  - Millions of vehicle recalls have been necessary to correct software problems
  - Cyber researchers have demonstrated successful remote control of vehicles
- Current technical standards for car software are far less stringent than those for avionics or rail safety. Vehicle software has been shown to be poor quality. Manufacturers cheat and lie (e.g VW)

Examples of software problems in cars

- 2005 Toyota Camry uncommanded acceleration claims
  - see Michael Barr's expert report in the Bookout v Toyota lawsuit. http://www.safetyresearch.net/Library/BarrSlides_FINAL_SCRUBBED.pdf
  - Barr inspected the electronic throttle control system code. He stated that he found buffer overflow, invalid pointer dereferencing, stack overflow, undetected task death, unsafe casting, race conditions and >80,000 violations of MISRA-C coding standards.
- In Nov 2013, Honda recalled 344,000 Odyssey vans for a software bug that could cause sudden braking.

http://www.autonews.com/article/20131102/OEM11/131109934/honda-to-recall-344000-minivans-in-u.s.-due-to-braking-glitch

Jeep owners urged to update their cars after hackers take remote control

Security bug allows remote attack of Uconnect system, letting hackers apply the brakes, kill the engine and take control of steering over the internet

The Jeep Cherokee is vulnerable to remote cyberattack that allows hackers to take control. Photograph: NRMA Motoring and Services/Flickr

Software Updates

- The current UK Government proposals require the “motorist” of an AV to install all the required software updates.
- New software might radically change vehicle behaviour.
- How much testing of each update would be required?
- The updates will presumably have to be wireless. They may take many minutes to download and install (currently, a satnav update can take more than an hour)
- Must be parked and update complete before moving? What if reception is poor or non-existent? Or if the update fails or “bricks” the car?

Software Maintenance

of 100 million lines of software

- Will motor manufacturers guarantee maintenance for the life of the car? 20 years? More?
- Will third-party software maintenance be possible, or permitted?
- Should the MOT test be changed to require that all known cyber vulnerabilities have been fixed …
- … and to fail any car where the software is no longer maintained?

Liability for Accidents

- How will police / insurers / regulators establish what caused an accident?
  - Machine Learning systems cannot explain (or be understood even by developers)
  - Vehicle data is proprietary and manufacturers have a conflict - and are known to lie
- Government proposes that the insurer must be liable**, even for accidents caused by hacking** and will reclaim costs from car companies if the car was at fault.
- Government naively assumes that manufacturers and insurers will establish quick methods for agreeing liability!
- Will there be international standards for what data must be recorded by AVs, and for the data formats? Must all the software code be held in escrow so that investigators have access?
- The absurd legal presumption that a machine is working correctly must be overturned!

Ethical Issues

- Faced with an inevitable collision, should an AV protect its passengers even if that means injuring others?
  - In surveys, people say AVs should minimise total casualties - but that they wouldn't ride in a AV unless it was designed to prioritise passengers.
- Manufacturers suggest that the car should collide with another car rather than with a person
  - Which would make it easy for someone to trigger a crash
- How should the privacy of personal data from an AV be protected?

Cyberattack is a Tier 1 Threat

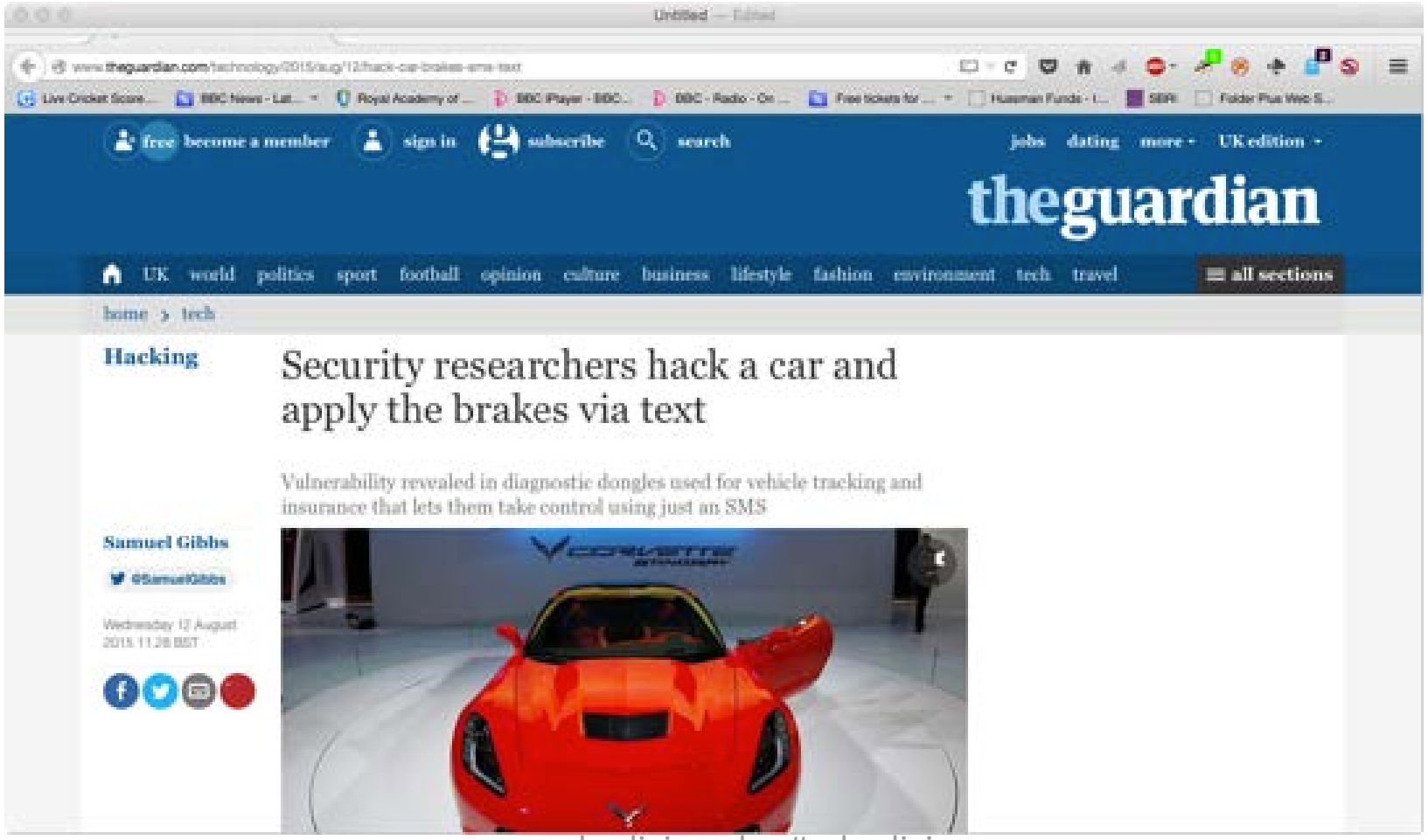
- The scale of the threat depends on attackers having **motive, technical capability and vulnerable targets**
- Potential attackers range from child vandals and hacktivists to criminals, terrorists, and hostile nations
- AVs will be critical national infrastructure – imagine the harm that could be done through remote take-over of a fleet of vehicles. Or a driverless car bomb. Or remote control of a driverless lorry

Every external source of software or data provides an opportunity for cyberattack

- Even the digital radio may be used to take over controls
- GPS can be jammed or spoofed - jammers cost just a few £
- Software updates advertise vulnerabilities and can be hi-jacked
- Mobile phone apps are particularly vulnerable
- Any weakness in the supply chain makes the end user vulnerable
- Most security depends on penetration testing - which can *never* provide high assurance

Even a text message can cause a buffer overflow and give an attacker control of the car

This was a buffer overflow attack on a car using a text message, but ***any digital data interface may be vulnerable to a buffer overflow attack.***



Conclusions on Cybersecurity

- Cyber risk is a real and growing threat to all computer-based systems, **especially if they are networked**
- The underlying problem is the poor quality of almost all software
- There is no strategy, in the UK or anywhere else, to tackle the lack of strong software engineering or to harden or replace critical software components
- There is a desire and irresistible pressure to introduce new computer-based systems
- The cyber risk will inevitably get worse.

The transition to Driverless Cars

- In Level 2 cars, the driver must monitor the automation *at all times*. "It's like teaching your children to drive, only quieter and even more tiring".
  - **It seems certain that drivers will become distracted**
- In Level 3 cars, the driver must be able to resume control quickly in response to an alert
  - **There is no regulation yet specifying how quickly**
  - Simulator tests suggest that several seconds is required – up to 20 before full driving competence
- Level 4 and 5 cars will be bullied by other cars
- **It seems possible that accident levels will rise at first**

The transition to Driverless Cars

- What proportion of Level 5 cars will be needed on the roads before the main social benefits are realised?
- If the benefits are slow in coming, and accidents are attributed mainly to human drivers, might there be pressure to restrict human driving?
  - Segregated roads, times of day, motorway lanes

Might it become socially unacceptable – or illegal – to drive oneself?

Conclusions

- The technology and social problems for safe and secure L5 cars will not be solved in a decade, but money and politics will ensure they arrive sooner.
- L3/L4 cars rely on drivers resuming control when the automation cannot cope. This will lead to a lot of accidents and disputes about what happened. These will be difficult and expensive to settle.
- The social implications are not understood

Is society ready for driverless cars?

Cars That Think

IEEE SPECTRUM

About the sensors, software, and systems that are making cars smarter

11 October 2017

Report: Waymo to Announce True Robocar Service

In line with Sergey Brin's famous promise, five years ago, to have a self-driving car on the road within five years, Waymo is about to announce that its robocar ride-sharing program in Phoenix will dispense with its backup driver. If the story, first reported at The Information, proves true, that would make the car service the first-ever commercial application of true self-driving technology.

Is Society Ready for Driverless Cars?