Road Safety Factsheet

August 2018

Autonomous Vehicles

In the last decade, vehicles have become increasingly autonomous, performing tasks for us such as automatically operating window wipers and lights. Technology has also developed within vehicles to assist us with the driving task, including features such as park assist, reverse cameras, cruise control and lane assist.

The automation of vehicles is set to become more widespread, with the emergence of advanced sensing devices and new on-board processing capabilities. This will mean that less and less input is needed from the 'human driver' during the driving task. This could also lead to shifts in the way that cars and other vehicles are used and owned. In fact, the results of some advanced trials suggest that some automated vehicles are already able to operate reliably in some contexts, but variable performance in other conditions means that these technologies will need to be further developed before autonomous vehicles become a common sight on Britain's roads[1].

What is an autonomous vehicle?

A fully autonomous vehicle is capable of completing journeys safely and efficiently, without a 'human driver' in all road and weather conditions. In this type of vehicle, occupants are able to engage in tasks other than driving for the entire journey[2]. However, there are varying levels of automated vehicle:

Table 1: Levels of driving automation[3]

Level	Name	Definition	Execution of steering and acceleration/deceleration	Monitoring of the driving environment	Fallback performance of 'dynamic driving task'	System capability
Human driver **monitors the driving environment**						
0	**No automation**	All aspects of the dynamic driving task are performed by the human driver, even when enhanced by warning 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 and or acceleration/braking using information about the driving environment. The human driver performs the rest 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 and braking using information about the driving environment. The human driver performs the rest of the dynamic driving task.	System	Human driver	Human driver	Some driving modes
Automated driving system- system monitors the driving environment						
3	**Conditional automation /semi automated**	The driving mode specific performance by an automated driving system of all aspects of the dynamic driving task. The human driver is expected to respond to a request to intervene.	System	System	Human driver	Some driving modes
4	**High automation**	The driving mode specific performance of an automated driving system of all aspects of the dynamic driving task, even if the human driver does not respond 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 dealt with by a human driver.	System	System	System	All driving modes

Challenges faced

As vehicles become increasingly autonomous, a number of challenges will be faced, which may require changes to road safety policy and law:

Driver licencing, testing and training

As highly and fully autonomous vehicles are developed, decisions will need to be made as to whether occupants of the vehicle will need a full driving licence as required for conventional vehicles or whether those with a modified driving licence will be able to operate highly autonomous vehicles that are likely to need less input from the 'human driver'. This could work in a similar way to the current system of driving licences required for manual and automatic transmission vehicles.

Vehicle roadworthiness

As with existing conventional vehicles, autonomous vehicles will need to be continuously maintained and kept in a roadworthy condition, which is likely to include regular software updates. This means that the MOT test may need to be altered to ensure that highly and fully autonomous vehicles have the latest software updates installed to pass the test.

However, if it happens to be much more expensive to fix or replace components of autonomous vehicles, users may choose not to conduct regular repairs and maintenance on their vehicles, which could pose a road safety risk to themselves and other road users.

Motor insurance

Motor insurance rules will also need to be altered to accommodate fully autonomous vehicles. Under the current system, motorists must hold compulsory third party insurance to compensate victims of any collision, regardless of who is at fault. When victims are injured by uninsured or untraced drivers, the Motor Insurance Bureau step in as an insurer to ensure that victims are compensated fairly and quickly.

In a collision with a highly autonomous vehicle, the fault of the accident could lie with the driver who failed to intervene when the system required them to or in the case of a failure of technology, the manufacturer. The Association of British Insurers recommend that motor insurance is extended to cover autonomous vehicles, rather than placing product liability on the manufacturer.

The government has consulted on proposals to

- Extend compulsory insurance requirements for automated vehicles so the owner must ensure that there is an insurance policy in place that covers the manufacturer's product liability.
- Require compulsory product liability insurance for automated vehicles to also cover injuries to the 'not at fault' autonomous vehicle driver as well as passengers and third parties.
- Develop a system to classify an automated vehicle so that manufacturers, insurers and consumers

know which vehicles this requirement applies to.

- Extend the Motor Insurance Bureau's role and the Uninsured Drivers Agreement and Untraced Drivers agreement to cover the new mandatory product liability insurance requirements for autonomous vehicles.

In response to the consultation, the government said that it would modify the proposals in the light of the feedback of the insurance industry. The government have decided to extend compulsory motor vehicle insurance, creating a single insurer model to protect victims where the autonomous vehicle causes a crash when it is in automated mode. The victim will have a right against the motor insurer and the insurer in turn will have a right of recovery against the responsible party to the extent there is a liability under existing laws, including under product liability laws[4].

Infrastructure

Automated vehicles will gradually enter Britain's roadway system. Before our roads are used solely by fully automated vehicles, a long transition period is expected where roads will be shared by fully automated vehicles, partly automated vehicles and manually driven vehicles[5]. Therefore, during this transition period, it will be vital that infrastructure is appropriate for all types of vehicles.

Signing and lining will be particularly important as vehicles transition from being conventional to fully autonomous. This is because increasingly autonomous vehicles are likely to rely heavily on clear and visible lines for lane keeping and signs for speed limit compliance and hazard warnings until a time when GPS signals and other technology offer full support[6].

Some current crash countermeasures may be needed less than they are now in the future. Proving their economic benefits may become more difficult as a result. For example, crash barriers may be required less and the economic benefits of roundabouts over signal-controlled crossroads may be diminished. However, there is a need to keep conventional crash countermeasures during the transition as they will continue to achieve good cost-benefits[6].

Benefits of autonomous vehicles

There are a number of expected benefits as increasingly autonomous vehicles emerge on Britain's roads.

Reducing road casualties

Automation can prevent crashes and limit injury and reduce risky behaviour and provide support to high risk groups in high risk situations[7]. As fully autonomous vehicles will reduce or eliminate the element of human error, it is likely that road crashes and the number of casualties will be significantly reduced.

In 2016, 1,792 people were killed, 24,101 were seriously injured and 155,491 were slightly injured as a result of a reported road accident on Great Britain's roads[8]. Human error is considered a contributory factor in around 90% of all fatal road crashes [1]. As automated vehicles are not subject to being driven impaired, driven while texting or subject to other forms of distraction such as being fatigued, it is likely that there will be a reduction in collisions. However, it must not be believed that human error has been correctly identified as a contributory factor in collisions or that all crashes could have been otherwise avoided by addressing that error. Many crashes that involve human error also involve other factors that may have still contributed to the crash even if the human had not made a mistake. Errors linked to poor roadway design or faulty vehicle design are often attributed as human factors, when they are in fact design errors [1].

One way in which automated vehicles could reduce the number of road casualties is through speed limit compliance. On 30mph roads, just over half of drivers tend to travel above the speed limit and 20% travel at more than 35mph[9]. However, in future, driving speeds will be controlled by the system. Evidence suggests that the risk of fatal injury to a pedestrian hit by a car travelling at 30-40mph is 350-500% greater than vehicles travelling below 30mph. Therefore, suburban accident rates could be reduced dramatically by this change alone. Sensors that are expected to be installed in automated vehicles are likely to be much faster and more reliable at detecting and avoiding vulnerable road users than most drivers today. This could provide large reductions in road casualties for vulnerable groups such as children, the elderly and cyclists[10].

A SWOV forecast has suggested that by 2020, developments in the field of vehicle automation could result in an annual decrease of 10 road deaths and 300 serious injuries in the Netherlands alone. The forecast for 2030 is that this decrease in road casualties will be around 10 times higher, meaning that for the Netherlands there could be a reduction of around 90 road deaths and 3300 serious injuries per year. This does not include the effects of new technology such as electronic stability control being introduced to vehicles, which is expected to reduce the number of road deaths by around 10% per year and the number of serious injuries by 100 per year for 2020 as well as 2030 [7].

A study by the University of Michigan Research Institute[11] and a study by Virginia Tech Transportation Research Institute[12] found that automated driving systems were characterised by much lower crash rates than conventionally driven cars. However, the small number of automated vehicle driving system involved crashes, none fatal (although this has changed since the time these studies were published), make the results statistically insignificant. For this to change, automated driving miles travelled and incidents reported would need to be scaled up considerably. It must also be noted that the majority of test kilometres driven are generally in sunny clear conditions on wide, uncomplicated roads, not necessarily representing the average road. The system would be unable to function in extreme conditions often faced by human drivers. This is a sensible approach for testing the technology but it must be noted that results could bias safety assessments[1].

There is an expectation that driverless cars and autonomous systems will deliver a 'near zero' harm solution for everyone, including vehicle occupants and those termed 'vulnerable road users' such as pedestrians and cyclists. However, 'near zero' does not mean absolutely zero, as there could be times where the driverless vehicle will be forced to choose between options where there is no outcome that avoids harm to all road users.

Therefore, a full application of the Safe System approach is still recommended, taking into account the possibility of technology failures of autonomous vehicles, acting as a fall-back solution. The system should be built to tolerate human and machine errors, preventing death and serious injury in the event of a collision[1]. The Australasian College of Road Safety describe Safe System countermeasures as aiming to either prevent a crash from occurring or to reduce the severity of that crash while minimising the possible role of human error in precipitating the crash[13]. Safe System measures include central and nearside barriers that prevent vehicles striking one another head-on and dedicated facilities for vulnerable road users that provide separation such as cycle lanes [6].

For more information on the Safe System approach, read our factsheet.

Mobility benefits

Autonomous vehicles could also bring significant mobility benefits to groups who currently face barriers to using personal vehicles. These groups include younger people, elderly people and disabled people.

Young people

In a survey of 3,000 adults living in the UK, young people stated that cost was a barrier to their mobility. The high costs of learning to drive, owning a car and insurance premiums can restrict freedom to travel. Despite national schemes to aid young people such as the 16-25 railcard, which offers a third off rail fares for young people, public transport is often viewed as an inadequate substitute for driving, particularly in rural areas where public transport is less frequent[14].

It is expected that young drivers may benefit from reduced insurance premiums in future due to the lower crash risk in autonomous vehicles. This is likely to be of particular benefit to those living in rural communities, who may find alternatives to driving such as public transport more difficult to access[10].

Elderly people

Compared with younger generations, older people are more restricted in terms of mobility. Of those aged over 70, 31% of people have problems walking or using a bus compared to just 3% of those aged 16-49[15].

Beyond the age of 65, there is a fall in the proportion of people with access to a car, with some people deeming themselves no longer fit to drive. Poorer eyesight, health, increased reaction times and reduced awareness are just some of the reasons that some older people no longer feel confident driving. This means that a proportion of older people rely on public transport, taxis and assistance from carers, relatives or friends [14]. With the 75 and over age group projected to grow by half by 2029, compared with only an 8% growth in population for 30-44 year olds, mobility demands of the ageing population are set to increase. It is expected that fully autonomous vehicles may be able to address these growing mobility needs.

Disabled people

Disabilities are thought to affect around one in five people, with around half citing mobility problems, equating to approximately 11% if the population[16].

This reduced mobility has negative consequences for those with disabilities, including limited access to education and employment. 36% of disabled people in a study of 3,000 UK adults cited infrequent public transport as a barrier to their mobility. By addressing issues related to mobility, there is a potential for those with disabilities to access education and in turn well-paid jobs. Therefore, highly and fully autonomous vehicles have an important role to play in addressing the deficit in education, social and job opportunities that disabled people face [14].

Risks of autonomous vehicles

Despite the benefits of autonomous vehicles, there are also a number of risks faced, particularly during the transition period where conventional, semi-autonomous, highly autonomous and fully autonomous vehicles will share the road.

Over-reliance on technology

As automation in the vehicle increases, the role of the driver will move from one of a vehicle operator to a system supervisor[17]. The difficulty stems from ensuring safe driving performance when vehicles are semi or highly autonomous. The challenge of this is keeping the driver, who may need to take control of the vehicle at any time if the system requires them to be kept 'in the loop'. Drivers may not pay much attention to their 'driving' if they believe that the technology will prevent them from crashing no matter what. This is related to a number of 'ironies of automation' because far from alleviating the driving task, partially automated systems which require the human driver to take control of the vehicle may lead to complex decision making environments and risks of unintended consequences. These ironies are:

- Task allocation: poorly adapted task allocation occurs when easy tasks, which the average human driver can handle well are allocated to automated driving systems leaving only the most challenging tasks to the human driver, leaving potential for error or unsafe outcomes. Automation should target the tasks that are difficult or in some cases impossible for human drivers[1].
- Disengagement: a lack of practice or imperfect situational awareness leads to reduced skill and delays in humans carrying out driving functions when they are required to do so by the system[1]. it could even be dangerous to assume that drivers can safely take over control from an autonomous vehicle in time to avoid accidents and injury. Highly trained commercial aviation pilots sometimes take minutes to detect the need to takeover and determine an appropriate response. In the vehicle, drivers are often relatively untrained and highly distractible, yet time for corrective action is seconds rather than minutes[18].
- Cognition: lack of engagement in the driving tasks leads to lower levels of situational awareness and longer reaction times when the automated driving function disengages and asks the human to take control. Simply supervising the situation does not offer enough engagement to keep the driver vigilant. Drivers may also easily become bored and begin to engage in distracting activities that can limit the speed and effectiveness of system handovers [1].
- Control: driving is a skill that needs to be practiced regularly to be perfected. The less time spent driving and less recall of the physical 'feel' of the vehicles can lead to an unsafe driving response in the form of poor steering, acceleration and deceleration[1]. This could be particularly problematic for young drivers who begin their driving career in these vehicles. They may not have the ability to anticipate situations in which they will need to control and drive the vehicle.

The issue of transition of control and being 'out of the loop' potentially becomes a serious problem in interactions with vulnerable road users such as cyclists and pedestrians. If it takes too much time for the driver to take over when needed, they may not be able to avoid a crossing pedestrian or cyclist in time. The occasionally rather unpredictable behaviour of pedestrians and cyclists could well be the reason that the automated system malfunctions and the human driver is asked to take over [5].

Therefore, these challenging machine to human transitions should be avoided. Some have suggested that conditional and highly autonomous vehicles should be avoided and several players in the field share this vision, designing systems that completely jump over intermediate levels of automation. This avoids the potential for crashes that result as human drivers take over from automated systems [1]. it is not clear how realistic this option is. Other solutions that have been suggested aim to keep the driver 'in the loop' so as to remain attentive include software that demands drivers to keep their hands on the steering wheel and the use of eye-tracking software to warn drivers if they move their eyes from the traffic situation. However, the question arises as to whether automated driving would be attractive for drivers if they still had to act like they were driving. It is also important to consider the effects of this solution for pedestrians and cyclists. Seeing a driver holding the steering wheel and looking in your direction could suggest that they are actively in control, whereas this may not necessarily be the case. Although it is not yet known whether pedestrians and cyclist respond differently to automated and conventional vehicles, it is imaginable that they could become confused or incorrectly interpret the assumed non-verbal communications of the driver[5].

Data security

In 2016, the cybersecurity vulnerabilities of connected vehicles were revealed through a series of highly publicised cyber-attacks against a vehicle in the United States. In these attacks, the vehicle's safety-critical performance was compromised, leaving the vehicle unable to move in heavy traffic.

There is no single threat that may target automated driving systems or even the traffic system, as threats are multiple, with varied motives and capabilities. Threats arise from hobbyists, organised criminals and state and quasi-state actors. Not all of these parties would seek to directly or indirectly cause a collision, but some would. If these vulnerabilities are left unaddressed, such attacks could be carried out resulting in negative safety outcomes [1]. Therefore, manufacturers of vehicles will need to meet security standards for data protection and cyber security to prevent hacking. If there are collisions or identity theft where a driver has not installed the most recent security updates to the vehicle, it will need to be decided whether the insurance company will collect this cost from the driver.

Interaction between autonomous vehicles and other road users

As there will be a transitional period in which conventional vehicles, semi-autonomous, highly autonomous and fully autonomous vehicles will share the road, drivers will need to have an understanding of the various types of vehicles. The public will also need to be aware of the performance abilities and limitations of these vehicles.

So far, it can be concluded that automated vehicle technology has mainly focussed on the detection and recognition of pedestrians and cyclists by the vehicle and although good progress has been made, many difficulties are yet to be overcome. For example, this technology is not yet operational in adverse weather conditions. Technology to reliably predict intentions and behaviour of cyclists and pedestrians, so that the automated vehicle can adjust its behaviour is crucial for safe interaction between these vehicles and pedestrians and cyclists. However, this is not straightforward as it can be very difficult for an automated system to predict behavioural intentions of pedestrians and cyclists [5]. The idea that pedestrians and cyclists will respond differently to partly automated vehicles also cannot be ignored. The few studies that have examined the behaviour of pedestrians and cyclists in interaction with automated vehicles found that they were fairly cautious and not per definition confident of its 'skills'. Pedestrians and cyclist were found to appreciate messages and or signals from indicating whether the vehicle had detected them and what it intends to do [5].

In current interactions between pedestrians and cyclists and conventional vehicles, informal rules and non-verbal communication are important aspects of communication. However, with the increasing level of automation, this type of communication will lose its function from the perspective of the vehicle and the pedestrian or cyclist. It will be very difficult for the vehicle to predict the behaviour of pedestrians and cyclists if they do not use the formal non-verbal communication cues such as using an arm to indicate a change of direction. Informal cues are generally subtle and therefore difficult to read. For pedestrians and cyclists, interaction with automated vehicles implies that they cannot rely on informal communication cues anymore. The effect of making eye contact with or smiling to a 'car driver' is not the same if the driver is not the person who is controlling the car and may be involved in completely other tasks, such as reading the newspaper or typing a text message [5].

For these reasons, developers need to strive towards reducing the uncertainty of what the autonomous vehicle is going to do in a traffic situation if they want it to function safely and efficiently. The majority of proposed solutions for autonomous vehicles to human communication consist of adding visual cues to the vehicle's exterior, such as LED light strips and panels or projections on the road in the form of laser light drawings. For instance, there could be light strips with messages such as 'I'm waiting' or 'Safe to Cross'. These seem reasonable when communicating with a single road user such as a pedestrian preparing to cross a quiet road. However, when viewed in the context of a busy, more complex junction with many pedestrians and vehicles, the visibility and understandability of these signals could be brought into question[19]. This means the exact messages and method of communication need to be studied further. These and many other questions will need to be answered in order to ensure that further developments towards automated driving will not result in a traffic system that is less safe for pedestrians and cyclists than it is currently [5].

RoSPA's position

As vehicles become increasingly autonomous it is essential that drivers understand the technology in their vehicles, what it does, how to use it safely and the potential risks of misuse. Drivers should receive vehicle familiarisation training when they receive new vehicles, including the safe use of technology, particularly if their previous vehicle did not have it. Drivers need to be alert and ready to take control of their vehicle at any time and therefore must not engage in other tasks such as making phone calls or writing texts or emails during driving time, as they are still in charge of the vehicle.

If used properly autonomous vehicles have enormous potential to reduce crashes and casualties, but if they are not used properly, they can also increase risk, especially if drivers over-rely on the technology.

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