Driverless vehicles: from technology to policy

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Conference Report

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1 INTELLIGENT MOBILITY AND VEHICLE AUTOMATION

The introduction of automatic systems is taking place in many areas of society. Manufacturing, retail, and the mining industries are increasingly reliant on automated procedures while automation is entering the domestic environment in the form of building control and communications. The transport environment is transforming into the context of intelligent mobility which brings together the engineering themes of robotics and automated vehicles with cloud/big data applications to connected vehicles and traffic management. Future mobility technologies are expected to reduce congestion and environmental impact while improving safety and transport efficiency and higher levels of automation are expected to give benefits by increased mobility to people who might not have any mobility options.

The UK Departments for Transport and Business Innovation and Skills have identified Intelligent Mobility as a highly important approach to address transport challenges and have estimated it has the potential to become a £900 billion industry world-wide by 2025.

The emerging Intelligent Mobility industry is considered an important business opportunity nationally with the potential to contribute substantially to future GDP. The UK is seen as an ideal location for research and development of Intelligent Mobility systems due to its science and innovation base and the existence of an ideal test-bed of highly congested roads. In 2014 the Transport Systems Catapult was established by DfT and BIS to act as a focus for research and development in this emerging market. With an initial funding of £150 million the objective of the Catapult is to initiate new research and innovation in Intelligent Mobility and to bring together the academia and business and to promote the capabilities of the UK.

The conference *Driverless vehicles: from technology to policy* has been organised by PACTS and Thatcham Research following the recent initiative of the Department for Transport to support trials of automated vehicles. The trials have been supported by a £10 million grant and will enable driverless vehicles to be operated in up to three UK towns. Increasing levels of automation seem inevitable and have raised the possibility that driverless vehicles might make a significant contribution to casualty reduction. The objectives of the conference were therefore to increase the understanding of the current and future capabilities of driverless vehicles and to clarify the potential impact on road safety.

2 THE INTRODUCTION OF AUTOMATED SAFETY SYSTEMS TO VEHICLES

Automation is expected to be at the heart of intelligent mobility and will be based on the concepts of connected road users, vehicles and traffic management and several car manufacturers have already indicated they will be selling partially autonomous vehicles by

2020 including Volvo, Nissan and others. Higher levels of automation are expected to be introduced incrementally although rapidly following improvements in technological capability and the early systems are typically intended to improve safety. These systems may have a limited effectiveness but may introduce a suitable platform for later technologies that are much more capable, this is illustrated by the progressive introduction of braking systems of increasing complexity and capability.

The first automated safety technologies to be introduced into vehicles were anti-lock braking systems that enabled the driver to continue steering under maximum braking conditions. Although there was the expectation that there would be significant numbers of collisions prevented this was not observed in real-world studies and the impact on safety was low.

Nevertheless the availability of the sensors, actuators and control mechanisms needed for anti-lock braking systems provided a platform for electronic stability control systems (ESC) which enable drivers to remain in control of vehicles in under-or over-steer conditions. Loss of control crashes are particularly common, especially under adverse road surface conditions or hard cornering and ESC has been observed to prevent crashes by typically 20%. More recent developments have resulted in ESC becoming a platform for a further safety system Autonomous Emergency Braking (AEB). Cars equipped with this system can detect other vehicles ahead and will activate the brakes in the event of an impending collision. The most advanced systems can now detect pedestrians and cyclists and will operate at speeds up to 50 kph. Low speed AEB systems have been observed to prevent up to 40% of front to rear crashes which have a high risk of whiplash injury.

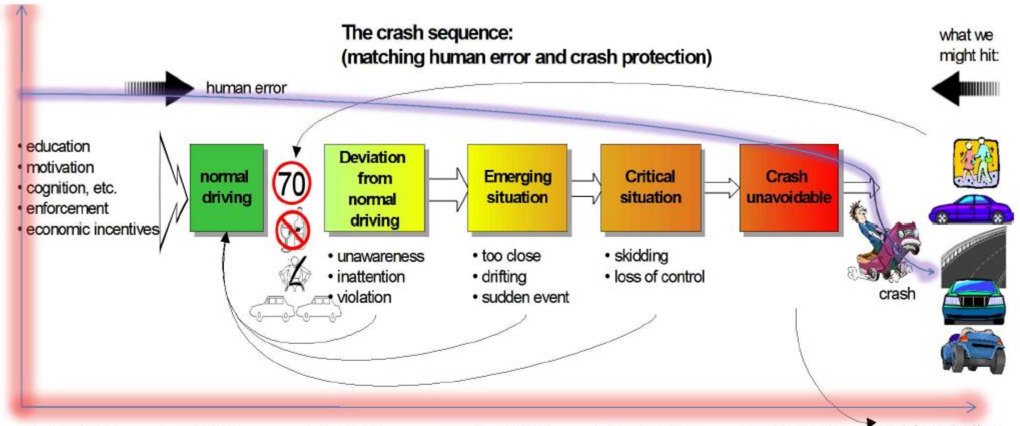
Many other safety and convenience systems are now on sale in the market with functionality that is based on the application of sensors, actuators and control systems. The safety benefits of many have not been evaluated in real-world studies and may in fact be modest however the availability of the systems opens the possibility of increasing future automation. For example low speed autonomous parking systems may be seen as a precursor to higher speed automated steering. Low speed platoon driving systems with autosteer such as those demonstrated by Mercedes may be the basis of future high speed convoy driving systems. Collectively the systems provide a platform with the potential to support the introduction of vehicles with high levels of automation where the driver is not required to continuously monitor the vehicle and traffic environment. The near-term introduction of intelligent safety systems therefore provides one part of the pathway to a highly automated mobility environment.

To support UK participation in what is expected to be a large emerging market the Government has recently announced funding to support trials of automated systems in UK cities. In the US several states including California and Nevada have developed regulation to permit autonomous cars to be used on the roads and in Sweden the city of Gothenburg and Volvo plan to start trials of automated cars in 2016. With the need to support evidence based policies governments are presented with a series of questions.

- What evidence is there for the casualty reduction benefits of the new safety systems?
- What factors might impact on the effectiveness of the safety systems?
- How can policy-makers promote the introduction of effective safety systems?

3 WHAT EVIDENCE IS THERE FOR THE CASUALTY REDUCTION BENEFITS OF THE NEW SAFETY SYSTEMS?

A model of the crash sequence has been presented by Tingvall on the basis of the Safe System Approach. It is illustrated below and indicates the transition from a normal driving situation through to an unavoidable crash.



• access to road transport system	• comfort • economy • social conformity	• warning system • supporting system	• intervention in driving	• immediate correction	• preparation for crash	crash protection
Vehicle	promote normal driving	(ISA, SBR, alcohol interlock)	(AICC, LDW)	(ESC, LDA, AICC2)	(pre-safe, emergency braking)	(seat belts, airbag, whiplash protection, pedestrian protection)
Infrastructure	promote normal driving	(speed warning, tactile warning, humps)	tactile edge lines	high friction surface		barrier design, roundabouts
Others	promote normal driving	• enforcement • insurance • contracts				• emergency service

Ref: Claus Tingvall (Swedish Transport Administration). The Safe System Approach

Normal driving represents the state where the risks of a crash are lowest and deviations away from this typically may refer to excess speed, alcohol or non-use of a seatbelt. Safety technologies that operate at this point can ensure that the use of the vehicle returns to the normal operating range and may provide warnings (eg seat belt reminders) or restrict the operation of the vehicle (eg alcohol interlocks).

Small deviations from a normal driving condition may develop into higher risk scenarios. Safety technologies with a modest level of intervention such as Lane Departure Warning or Advanced Intelligent Cruise Control may also either give a warning to the driver or take over some part of the vehicle operation with the objective of returning the vehicle to the normal condition.

Critical situations occur when the crash is close to being unavoidable and human drivers may be unable to effectively take control with the degree of precision required. Technologies that operate at this point such as Lane Departure Assistance or Electronic Stability Control take active control over elements of the vehicle operation such as steering or braking and aim to either prevent or mitigate the collision and warnings are no longer effective.

Once a crash occurs injury mitigation systems based on seat-belts, airbags and vehicle structures manage the collision energies and reduce the risk and severity of injuries. Advanced crashworthiness measures are now available in most cars and have been shown to be highly effective resulting in an average annual reduction of 2.6% in serious injury risk between 1990 and 2010.

Evidence of crash avoidance effectiveness under real-world conditions is scarce for many of these new systems. The research challenge derives from the relatively low numbers of equipped cars in the vehicle fleet, the difficulty in identifying vehicles equipped with optional safety equipment, and, if the systems are effective, the need to measure the absence of a group of cars from the accident population. These challenges are not insuperable but solutions require collaborative approaches between government and industry. Without these evaluations policy-makers frequently have to rely on projected estimates of potential savings using methods that are seldom validated and a true measure of performance remains unknown.

4 WHAT FACTORS MIGHT IMPACT ON THE EFFECTIVENESS OF THE SAFETY SYSTEMS?

The potential of automated systems to improve safety is clear however there are many factors that can reduce the casualty reduction effectiveness. These may include the introduction of new road safety risks (eg distraction) or reductions in effectiveness of a system from the experimental conditions (eg behavioural adaptation and over-reliance). There are also structural constraints concerning the safety functions selected for development, the impacts on a mixed fleet and the liability for any collisions that do occur.

Choosing the best safety technologies. The best road safety policies are based on the introduction of evidence based measures that incrementally reduce the risk of travel. These measures are normally based on road engineering, education, training, vehicle safety and the management of the road system. Automated safety systems are one of these measures and the UK support for industry to develop these technologies has been welcomed. However the technologies that are needed for higher automation may not be the same as those needed for the greatest casualty reduction, for example there is relatively little support for technologies that address the highest accident risk factors of speed or alcohol.

A long transitional phase. Highly automated vehicles will be introduced to the vehicle fleet over a lengthy period of time according to the pace of vehicle replacements and there will be a mixed fleet with some vehicles more highly equipped than others. Cars may be equipped with more capable safety equipment than motorcycles or pedestrians. Safety evaluations and predictions are based on assumptions of a fully equipped fleet and comparable vehicles and very little research has been conducted on the safety impacts during the transitional phase. For example how will vehicles with speed management systems operate in a fleet with unequipped vehicles – will the unequipped vehicles travel faster and continually overtake so that the speed management system is finally switched off by a dissatisfied driver? Will drivers take more risks knowing the vehicle has a range of safety systems? Will they rely on a drowsiness detection system to tell them when to take a break and drive for longer?

Accident liability. The allocation of liability in the event of a crash is a potential limitation in the deployment of more highly automated vehicles. With current systems the driver is expected to remain in control of the vehicle at all times and it is clear that the driver is liable should a crash occur. As long as the driver has the opportunity to take control over a partially automated car and avoid a crash the liability will remain with the driver. At the highest levels of automation however the driver will not be able to override the system and will be reliant on the operation of the vehicle systems, the vehicle manufacturer will therefore become liable. This transfer of liability has a significant impact on the decisions of manufacturers and the insurance market and means that the higher levels of automation will not be seen in the market until a new liability regime has been clarified.

5 HOW CAN POLICY-MAKERS PROMOTE THE DEPLOYMENT OF SAFETY SYSTEMS?

The current pace of technological innovation is very fast and market forces should take precedence over the early introduction of safety systems into the vehicle fleet. Once a safety system has been found to be sufficiently effective it may become necessary for regulation to ensure deployment across the new vehicle fleet but there are also other things that can be done to provide an environment that supports market acceptance and deployment.

A systematic monitoring and evaluation framework. This review has identified a major knowledge gap concerning the real-world performance of many safety and automated driving systems. Without accurate information about the true performance it is very difficult for manufacturers to identify the customer value, for policy-makers to promote the system and for consumers to choose any optional systems. There is currently no comprehensive approach that identifies and evaluates the operation and effectiveness of each system either at national or EU level. Although challenging it is possible to put in place a systematic monitoring and evaluation framework to provide feedback to manufacturers and policy-makers about their systems. The UK is strong in gathering accident and road safety data with the national accident database STATS 19 and the in-depth Road Accident In-Depth Studies (RAIDS). Together these support many road safety interventions and are fundamental to road safety but the programmes are not designed to focus on the performance of the automated safety systems that are in use on the road. A dedicated programme of research is needed to provide the detailed feedback necessary but this type of applied research lies outside the scope of the academic research funders such as the Research Councils. It would normally be supported by the DfT however current financial constraints prevent the research questions from being addressed and there is little sight of better safety data becoming available.

Full integration of road safety needs into other policies. Automated vehicles and safety systems do offer a significant opportunity to reduce casualties, however to achieve the greatest safety benefit it is necessary to ensure that all relevant policy areas properly incorporate road safety objectives. Policy concerning development of vehicle automation is focussed on the Departments of Transport and Business, Innovation and Skills and other national organisations including the Research Councils and Transport Systems Catapult also play a significant role. Transport is the lead agency in road safety but the mechanisms that ensure that road safety needs are fully represented in other relevant policy areas are not clear. Road safety must one of the key factors in determining which automated vehicle systems to support, for example by supporting systems with the greatest potential impact on road risk.

Promote high fleet penetrations of effective safety systems. A vehicle safety system may be highly effective in reducing crashes but if it is only an option to the car buyer then the real number of vehicles equipped may be much lower. Public actions to promote the best systems can have a large impact on the fleet penetration of a safety system. An example concerns the use of consumer information which enabled the Swedish Administration to raise the fitting rates of Electronic Stability Control in new cars from low levels up to around 80% before it was mandated. In comparison under purely market forces the penetration rate in the UK was around 35% of new cars.

6 Conference conclusion

The increasing introduction of automation into vehicles has the potential for significant safety improvements and early technologies such as ESC and low speed AEB have already demonstrated valuable crash savings. There are high expectations of the potential of further safety systems and the wider focus on automation and integration of transport within the context of intelligent mobility makes the introduction of further systems more likely. However there is no certainty that the full safety potential of automated systems will be achieved but several actions can improve this:

- Integration of road safety considerations within the policy support for automated vehicles
- Provision of an effective monitoring and evaluation framework
- Promotion of the most effective systems through public information, assessments of effectiveness and other incentives