Regulation issue

Many building blocks need to be put in place to enable autonomous cars to take to the roads safely with the public's blessing

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US regulation

In March 2016, a report was released by USDOT's Volpe National Transportation Systems Center on the applicability of current US Federal Motor Vehicle Safety Standards with regards to autonomous vehicles. "It shows there are few current restrictions on some automated vehicle concepts, which highlights the need to establish clear expectations for their safe operation," said Mark Rosekind, NHTSA administrator. "At the same time, for other vehicle designs the agency has more work to do to ensure the safety of new innovations, and we look forward to learning more from stakeholders as we start that work."

The report concluded that the designs without accommodation for a human driver – that is, equipment such as steering wheels and brake pedals – would not comply with current standards. NHTSA is working on operational guidelines. One of its aims is "determining what new regulatory tools and authorities might be required to meet NHTSA's safety mission in an era of rapidly changing technology". President Obama proposed a 10-year, US$3.9bn investment in the technology in January 2016.

(Above) **Google's self-driving cars are being tested on public roads, with test drivers ready to take over the controls**

Autonomous vehicles hold the promise of eliminating crashes caused by human error, but they are still a long way from full deployment. There are currently no vehicle regulations specifically aimed at autonomous systems. Homologation bodies are now working with OEMs and governments on the first umbrella legislation covering both autonomous and non-autonomous vehicles.

"There are two stages to achieving a common framework," says Alain Piperno, an autonomous vehicle expert and testing and homologation project manager at French test lab Utac Ceram. "By the end of 2017 we are likely to see regulations for the first autonomous vehicles, but only for highway use. Six or seven tests are at an advanced stage of development for this first draft of regulation. They include minimum risk maneuvers for when a vehicle gets into difficulty because of an internal fault or problems with the road surface."

Utac Ceram plans to open new testing tracks for autonomous vehicles in 2017, and to propose 30-40 tests for critical automated driving scenarios.

Virtual assistance

At higher levels of automation, where complex driving situations will be handled by a machine, testing will have to take into account a huge range of environmental conditions, driving abilities and emergency situations – a workload unlikely to be managed by road testing alone. "Virtual testing will be the key to the infinite number of possible driving scenarios," says Arno Eichberger, associate professor for automotive systems engineering at Graz University of Technology in Austria. "Stochastic scenario generation and intelligent algorithms will create new scenarios based on failed test cases. However, verification on human-in-the-loop and vehicle-in-the-loop test benches, as well as on-road testing, will still be necessary."

(Main) **Tesla's Autopilot system can steer down the highway, change lanes when the driver flicks the turn signal, and adjust speed in response to traffic; with drivers still expected to keep their hands on the wheel**

(Inset) **The range of the Model S's multiple sensors**

Sensors and V2X

Arno Eichberger of Graz University of Technology in Austria argues that a combination of sensors will be needed to build a robust 360° picture of the environment around the car, while V2X will be needed to anticipate dangers further ahead. "Each type of sensor has its own strengths, and so we need to combine data from them all," he says. "Long-range information, provided by V2X, can enable the car to reduce its speed ahead of danger areas, for example."

Is standardization needed for sensor hardware? "I would not recommend prescribing certain standards for sensors, but rather focus on standardization of the data that autonomous vehicles will share with infrastructure," says Eichberger. "Sensors have to be good enough to enable autonomous driving, but OEMs should be free to specify their performance with component suppliers."

Gunwant Dhadyalla, principal engineer at the University of Warwick's manufacturing group, WMG, foresees delays for the integration of V2X. "Companies looking for low-speed applications in autonomous vehicles are quite happy not to have connectivity yet," he says. "The industry is still risk-averse – it's looking for an independent autonomous car that doesn't have the added issue of cybersecurity. But in the long term I don't see how it can be avoided. We will want vehicles to be able to talk to each other and be aware of different situations, to enhance their capabilities. This is critical when you're dealing with a whole fleet of autonomous vehicles."

Gerben Feddes, senior advisor for intelligent mobility at the Netherlands' vehicle authority, RDW, wants to take testing even further. "In the future, a piece of software might legally be the driver of a production car, making the human driver a passenger in their own car. But where would the knowledge come from to drive that car safely? We believe it should come from the same people who devise and administer driving tests for humans. We're suggesting that maybe there should be a driver's license for cars."

(Above) Ford is testing its third generation of autonomous technologies at sites including the Mcity 32-acre proving ground in Michigan, USA

(Left) Ford has also started testing its technology in snowy conditions

Constant change

Feddes also says the evolving nature of software will necessitate radical reform of homologation procedures. "With software being constantly updated, a car is an ever-changing vehicle and there is no point in one-off admittance – you need to apply performance-based requirements," he says. "A car has to perform in a certain way and it's up to the manufacturer to produce acceptable means of compliance. We've learned from aviation and drone legislation – we're moving away from the how and beginning to focus on the what."

Another issue to settle is who is liable if an accident does happen. Where decisions leading to a crash are made by a machine, can some of the blame be laid at the manufacturer's door? With regard to its current, partially automated systems, Mercedes-Benz says "no". The company issued a statement in April 2016, as part of the Daimler Sustainability Report, which puts the onus on the consumer: "The legal situation in Germany and many other countries is clear: with regard to current, partially automated systems, the driver remains responsible. Although systems such as Lane Keeping Assist in the new E-Class provide support, the driver must still control the vehicle." However, the report did concede that "manufacturers are responsible for damages from product defects".

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75% of US drivers would be afraid to travel in autonomous cars

61% want AEB, ACC, parking assist or lane-keeping assist in their next car – **84%** citing safety as their main reason; **64%** citing convenience; **46%** wanting to reduce stress; and **30%** wanting the latest technology

84% of those who reject semi-autonomous features think the technology won't live up to their driving skills; **60%** think the technology is too new; **57%** don't want to pay for it; **50%** know too little about it; and **45%** find it annoying

23% of female drivers and **12%** of male drivers rejected the technology, at least partly for being too complicated to use

*Data from an American Automobile Association survey of 1,800 US drivers, published in March 2016

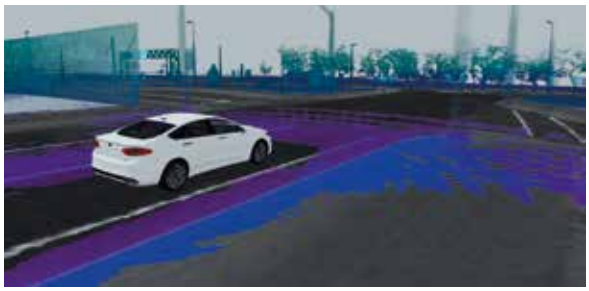
Model behavior

An academic department of the University of Warwick, WMG sees itself as a bridge between research and industry. More than 500 people work on the WMG campus, as well as at collaborative centers located in seven countries.

The department has developed the 3xD (drive-in, driver-in-the-loop, driving) simulator to allow repeatable, scientific study of connected and autonomous vehicles. It is housed in a shielded room, enabling control over all wireless signals that communicate with the vehicle. Features include vehicle-agnostic adaptive systems, infotainment and communications simulation, eye-tracking technology and remote-sensing technologies. Vehicles can be 'driven' on a 30-mile route, based on data captured through lidar scanning.

(Above) The WMG's simulator provides a safe environment in which to test autonomous driving functions

(Below) The purple areas are what the Ford Fusion Hybrid Autonomous research vehicle can see. Ford recently adopted new lidar sensors with a range of 200m



It remains to be seen who will be liable at higher levels of automation, with machines making most or all critical decisions. Volvo is looking into accepting full liability for collisions involving its autonomous vehicles.

"Discussions are underway in Europe and at the ISO on an aviation-style black box data recorder that could help determine who was in control during an accident – the driver or the vehicle," says Utac Ceram's Piperno.

Will there also need to be standards relating to HMI? What would be an acceptable driving mode handover period? In a 2015 simulator study by Mok et al at Stanford University, *Emergency, automation off: Unstructured transition timing for distracted drivers of automated vehicles*, most drivers tested were able to navigate through a road hazard when they were warned five seconds before entering it. However, a 2014 study, *Transition to manual: Driver behavior when resuming control from a highly automated vehicle* by Merat et al, indicated that it might take up to 40 seconds for participants to stabilize the vehicle after an alert.

Moral compass

In developing software for autonomous vehicles, there are also ethical questions to be addressed. Filippo Santoni de Sio is a taskforce member for ethics and robotics at the 3TU Centre for Ethics and Technology, run by the universities of Delft, Eindhoven and Twente in the Netherlands. He references a thought experiment by Patrick Lin, asking if the autonomous vehicle is faced with the stark choice of having to hit one of two pedestrians, a pensioner or a child, which should the vehicle select?

Santoni de Sio says there are four possible approaches to the problem. He rejects the first two, of leaving the decision to the programmers or the driver. "A third option would be a public debate, involving all stakeholders – from politicians to car makers and consumers – to arrive at a solution that might be right or wrong but shares the responsibility," he says. "Option four is to program the car to choose randomly, as if flipping a coin, effectively meaning nobody is responsible."

Santoni de Sio urges the industry to consider ethics before it is forced to. "If you look at the history of technology and legislation, the most realistic scenario is that an accident will happen before we have reached a consensus and society will decide afterward how to cope," he says. "I would prefer a public debate in advance, and to reach a shared decision with consumers, developers and policy makers."

TEST & DEVELOPMENT

Gunwant Dhadyalla, Arno Eichberger, Gerben Feddes and Alain Piperno are confirmed speakers at the **Autonomous Vehicle Test & Development Symposium 2016**, to be held in Stuttgart, Germany, from May 31 to June 2. Two sister events are also being launched this year: The **Autonomous Vehicle Safety Regulation World Congress 2016** and the **Autonomous Vehicle Interior Design & Technology Symposium 2016** will be held in Novi, Michigan, USA, on October 25-26.