Think piece

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The road to autonomy: driverless cars and the implications for insurance

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- The autonomous (driverless) car is on its way. There will be no “big bang” but introduction of increasing levels of automation over a number of years. In fact, partially autonomous vehicles are on sale now and are increasing in availability and system ability.
- Engineers face a huge challenge to create highly and then fully autonomous cars, which creates uncertainty about the timing of their availability.
- There are societal questions which must be answered before highly and fully autonomous cars are accepted and legal. The regulatory framework allowing highly automated cars on the road requires review.
- This change in the fleet will take a long time. It takes at least 10 years to get a new technology on every new car and a further 10-15 to get the majority of the UK fleet changed. Therefore the earliest we could predict a near 100% highly autonomous UK fleet by 2040 and a fully autonomous UK fleet by 2050.
- There are significant impacts on risk and the provision of insurance products. Ultimately, there will be a shift away from insurance for the driver towards insurance for the vehicle i.e. towards product liability insurance. In the transition, risk accurate information about the insured vehicle will become more important. For the moment, motor insurance remains essential as long as the driver is required to be in control.

CII Introduction: the development of so-called "driverless cars" has been heralded as one of the most important events in the motor insurance sector. Aside from their technological and lifestyle impact, which will be as significant as the introduction of private cars themselves, the implications for insurance are huge: potentially removing the human element to car operation brings into question some of the most basic principles of ownership and liability. This could have a fundamental impact on insurance, even down to how it is distributed. One of the key UK organisations involved in independently assessing the emerging technologies and understanding their implications for insurance is Thatcham Research, the world-leading automotive safety and security test centre. In this Thinkpiece, Andrew Miller, their Chief Technical Officer, considers driverless cars and the implications for insurance.

The development of driverless cars or more correctly "autonomous vehicles" could be one of the most significant developments in automotive technology since the introduction of the mass market car itself. Ultimately, in its full introduction in the longer term, users would be able to specify a destination in the way they use a satellite navigation system now, and then just sit back as the vehicle drives there in complete safety. "Taking over" manual control would be voluntary—if it is even permitted: there may be zones where automated control might be mandatory. On motorways or major carriageways, for example, it might be essential for automated cars to group together like flocks of migrating birds (an activity known as "platooning"), sharing data with one another and reacting in concert to the conditions around them. They would be able to maintain a steady speed and power, use less energy, and avoid major accidents. This vision will fundamentally change the way we use cars, how they are designed, and even how their cabins are laid out. It will in-turn have profound knock-on effects on other things. If cars could platoon together on motorways or carriageways, traffic jams might become less frequent, which will have implications on road usage everywhere. If cars could go away and park themselves after dropping off their occupants, offsite car parking would be possible, affecting local town planning. If car owners could perform other activities besides driving their journeys (such as sleeping), *and* not have to worry so much about parking any more, private car usage might suddenly develop a edge over public transport again.

Vehicles are now starting to have some systems which are autonomous in nature, and so the journey to a fully automated vehicle has already begun.

As significant as this development will be, its introduction will be an evolutionary process. In fact, some of the prerequisite technologies to bring this vision into reality are already either being tested, or have actually been introduced into the UK mass market and are on the road now. However the technology is now by and large in its infancy, and although there will be some landmark tests and demonstrations in the next few years, the transition to this world of fully autonomous cars will involve some further important technological, moral as well as ethical development before it does come to fruition. Least of all, for the insurance sector.

The drive to autonomy

Vehicles are now starting to have some systems which are autonomous in nature, and so the journey to a fully automated vehicle has already begun. The following are examples of autonomous technology systems, otherwise known as Advanced Driver Assistance Systems (ADAS), which are already available in vehicles in the UK mass market:

- **Park assist:** performs the manoeuvring tasks associated with parking using various sensors around the car, while the driver just controls the power/speed.
- **Autonomous Emergency Braking (AEB):** detects and tracks cars and other road users (eg cyclists and pedestrians) using radars, lasers and cameras, and attempts to avert/lessen collisions by warning the driver of impending impact threats and/or applying the brakes if the driver does not respond.
- **Adaptive Cruise Control:** whereas traditional cruise control that has been in cars since the 1980s simply maintains a set sustained cruising speed; adaptive cruise control uses sensors to detect and track traffic ahead and adjusts the vehicle's own cruising speed to maintain an adequate safe distance. Some systems will fully auto-brake if the traffic ahead slows or stops in an attempt to avoid or minimise collisions.
- **Electronic Stability Assist:** maintains the car's cornering trajectory if the vehicle detects under or oversteering through intelligent sharp single-wheel braking. This is an advance on Automatic Braking Systems that avoided wheel-lock in braking situations.

- **Lane departure warnings and lane-keeping aids**: detects the edges of the lane using cameras and other sensors and warns the driver of unintentional deviations. Lane-keeping aids actually manoeuvre the vehicle away from the verges using the electronic power-assisted steering.

All these existing ADAS technologies still largely leave to the driver the core vehicle operation functions, in the progression of increasing automation of first secondary and then primary driving tasks. In that respect, Volvo's introduction of AEB as a standard feature on its XC60 in 2007 was a milestone in that it was the first standard-fit collision avoidance system which detects an impending collision and actually brakes the vehicle at the last minute if no action is taken by the driver. In effect, the system actually *takes over one driving function* in an emergency (albeit as a very last split-second resort). That technology is now a standard feature in several new models by several manufacturers, and in 2014 was added to the Euro NCAP rating system, and is effectively a requirement for cars to receive Euro NCAP's coveted Five Star Rating.

Figure 1: Volvo XC60 AEB test at Thatcham Research

Source: Thatcham Research

These features that we are already starting to see in cars are made possible by what is known as "embedded intelligence" in the car systems. Embedded intelligence is logic (rules)-based software. For example, for the logic structure for AEB might be summarised as follows: *if* the forward-looking camera image contains a pre-defined pixel pattern associated with a car up ahead, *and* the radar detects and calculates that the car ahead and the driven car will converge within a certain time, *and* no preventative control inputs (steering changes and/or braking) are detected by the driver, *then* the emergency braking will be applied.[1]

Embedded intelligence is common in a range of mainly electronically controlled systems across a range of engineered objects – from central heating to automated trains. On this basis we also refer to "driverless cars", the presumption being that the lack of driver is because the car has embedded intelligence *equivalent to or superior to* that of a human driver.

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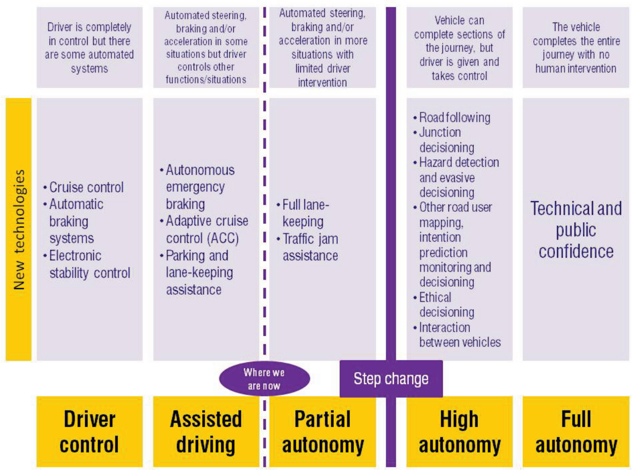
With each increasing level of autonomy new driving tasks will be possible for the vehicle to control itself based on its embedded intelligence. The following chart shows the progression of this and where we are in 2015 in terms of level of autonomy.

Figure 2: Levels of autonomy and where we are now



Source: Thatcham Research

As can be seen from Figure 2, there is a major step change when the embedded intelligence reaches more complex decision-making (the fourth column). Whereas the *if-then* logic for AEB described above involves the relatively simple task of detecting threats ahead and taking avoiding action; for complete autonomy, the system would need to be much more complex. It would need to bring together multiple sensory inputs combining accurate

[1] For more information on AEB and its effect in reducing collisions, see for example Thatcham's Autonomous Emergency Braking leaflet as part of its Stop the Crash campaign: www.thatcham.org/aeb

mapping and most importantly a database of rules governing actions/reactions compliant with for example the relevant highway safety code in the jurisdiction the vehicle is operating, along with an additional set of rules on safe 'advanced' driving techniques to anticipate and manage potential errors by other drivers or road users.

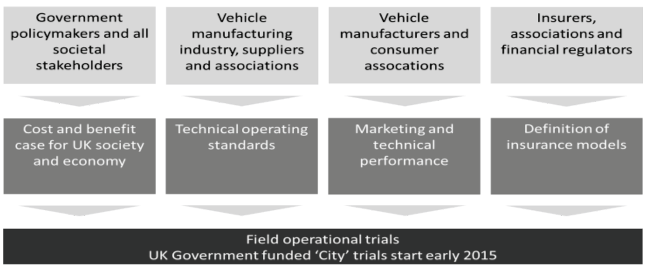
Embedded intelligence is not to be confused with Artificial Intelligence, which is usually defined as a machine which is a truly independent agent and which can, among other things reason, problem solve, plan and learn. Researchers in the field are also considering other intelligence attributes as part of this emerging definition, areas such as perception and creativity.

It may be that some manifestations of vehicle embedded intelligence will have a learning capability upon which the vehicle performance will depend in future; some researchers posit that this capability may be a pre-requisite for the embedded intelligence required to drive a vehicle due to the enormous numbers of logic 'rules' which would otherwise have to be written. However it is unlikely that this would be easy to manage within current product or liability regulation as it would be difficult to guarantee the vehicle system performance.

Stakeholders

There are a wide range of affected stakeholders. The societal risk of the use of vehicles is managed using a legal framework with agreed liabilities, and it is here that insurers can play their part in the development of the use of these vehicles.

Figure 3: A map of affected stakeholders



Source: Thatcham Research

Thatcham Research has and will continue to play a role in assessing the implications for the insurance sector and in undertaking independent and scientific testing of these new technologies.

The legal situation

Aside from the technology, there are significant hurdles which have to be consider from a legal, regulatory and liability perspective.

Road traffic regulation

In the UK, the Road Traffic Act 1988 regulates vehicles' use of the road but does not state in terms that the driver must be in control.

The UK Government (Department of Transport) are reviewing the issue of control, regulatory framework for testing and use of autonomous cars, insurance liability, tax, MoT, driving licence and revamped Highway Code – to be agreed by summer 2017. This follows on from the provision of funding in Autumn 2014 to 4 cities (Bristol, Milton Keynes, Coventry and London Greenwich) to pilot autonomous cars.

For the foreseeable future there will continue to be a requirement that the driver retains the ability to take control of the vehicle at any time. Similarly, requirements on the use of seat belts and prohibition of driving under the influence of drugs or alcohol or using a mobile phone remain.

However, this contrasts with the 1968 Vienna Convention on Road Traffic:

- Article 8 of the 1968 Vienna Convention: "Every moving vehicle or combination of vehicles shall have a driver….."
- Article 13 of the 1968 Vienna Convention: "Every driver of a vehicle shall in all circumstances have his vehicle under control so as to be able to exercise due and proper care and to be at all times in a position to perform all manoeuvres required of him."

A working party on Road Traffic Safety (WP.1) in the UNECE is developing a new clause referring to the technical regulations as well as including a broad definition of 'Driver Assistance Systems' [amendment April 2014]

In the USA, federal legislature lags behind. At state level, Nevada, California and Florida have passed legislation supporting testing of driverless cars.

For the foreseeable future there will continue to be a requirement that the driver retains the ability to take control of the vehicle at any time. Similarly, requirements on the use of seat belts and prohibition of driving under the influence of drugs or alcohol or using a mobile phone remain. Any development of the applicable regulations must provide for the different levels of automation in vehicles all occupying the same busy road space.

Product Regulation

Product regulation in many countries does not allow highly or fully automated driving. For example:

- ECE-R 79 (Steering Equipment)
- ECE-R 48 (Lighting)

These will have to be revised and national regulation revised in turn where necessary.

We are also likely to see increased vehicle-to-vehicle (V2V) communication requiring regulation – both as to the shared architecture and use of data.

In the UK, the approach adopted by law makers has been one of gradual accommodation of new technologies and the challenges presented by fully automated driving are unlikely to be any different – see further below regarding product liability.

One of the challenges for the immediate future for an international Original Equipment Manufacturer, component or technology supplier will be the variety of regulatory regimes adopted in different jurisdictions.

Product and other Liability

Early legal opinion (untested) is forming the view that existing product liability law can be applied to highly and fully automated driving, and it is not expected that a special liability law will be required.

The Consumer Protection Act 1987 provides a framework for redress where a defect exists within the car placing liability on the producer.

The vehicle manufacturers will have to review their insurance position very carefully:

- There will be increasing focus on the provision of information and training to car purchasers/users as to the level of automation in a particular product and what level of participation is required by the driver/user.
- Greater level of after sales care; technical updates and upgrades.
- Data protection: gathering of a great deal of commercially valuable and personally sensitive data during the use of a fully automated car creates risks.
- V2V communication requires collaboration between providers.

Test cases where accidents still occur may ultimately lead to industry agreements regarding apportionment of liability. This could also include consideration of a no-fault compensation scheme.

Potential advantages and disadvantages of autonomous vehicles

Advantages

- Increased road capacity and reduced traffic congestion due to reduced need for safety gaps and the ability to better manage traffic flow.
- Potentially higher speed limit.
- Removal of all constraints based on driver ability or state: a fully autonomous/driverless car could have passengers which are blind, distracted, intoxicated, under age, over age, or otherwise impaired.
- Reduction in the need for traffic police.
- Possible eventual reduction of physical road signage.
- Relief of vehicle occupants from driving and navigation tasks.
- Increased provision of data on the driver, their behaviours and locations now and in the immediate future allow for better risk estimation by insurers.
- Improved parking capacity: cars could drop off passengers, park far away where space is not scarce, and return as needed to pick up passengers.
- It is likely that intrinsically safe vehicles will have less collisions, leading to lighter more sustainable materials being used in manufacture.
- With fewer collisions thus the type and scope of vehicle insurance could change.

Disadvantages?

- Interplay between different levels of automation using the same road space – in the near future as increasing adoption of technologies.
- Moral/ethical choices: where an autonomous car's intelligence software is forced to choose between

multiple courses of action, all of which cause harm. Is this a decision taken by the motor manufacturer or by government?

- Overall intelligence software or vehicle sensor/system reliability.
- Cyber Security: a car's computer could potentially be compromised, as could a communication system between cars.
- Drivers being inexperienced if situations arose requiring manual driving and failing to pay sufficient attention as they rely increasingly on automation.
- Terrorism/Criminality: driverless cars could potentially be used by terrorists or other criminals i.e. they could be loaded with explosives and used as autonomous bombs.
- Health implications of increased car usage over public transport and walking: less exercise resulting in increased incidence of obesity.
- Loss of driving-related jobs.
- Cost of product given the level of automation
- Reputational risks for motor manufacturers – where many components are supplied by others.
- Impact of shared ownership of cars/reduction in individual ownership.

Predictions

Major automobile manufacturers and technology companies have made numerous predictions for the development of autonomous car technology in the near future.

- Volvo's XC90 (which went on sale in January 2015) features 'Adaptive Cruise Control with steer assist' which will automatically follow the vehicle ahead in queues.
- The Institute of Electrical and Electronics Engineers (IEEE) have estimated that up to 75% of all vehicles will be autonomous by 2040.[2]
- Tesla has just launched its "autopilot" feature with its 6.1 over-the-air software update.
- Estimates by Morgan Stanley indicate that autonomous cars could save the US economy $1.3 trillion annually through lower fuel consumption ($169 billion), reducing crash costs ($488 billion) and productivity increases ($645 billion).[3]
- KPMG LLP and the Center for Automotive Research (CAR) predict new business models and improvements in productivity and energy efficiency.[4]
- Autumn 2015 will see driverless "pods" on the (pedestrianised) roads of Milton Keynes and in 2016, the Bowler Wildcat (based on a Land Rover Defender) will run on campus of the University of the West of England in Bristol.

Opportunities and threats for insurers

Opportunities

- New channels/customers (e.g. manufacturers, car share programmes).
- New ancillary services (e.g. navigation, safety, emergency, vehicle maintenance).
- New risk products for insurers (e.g. Cyber-risk, micro-insurance).
- Commercial applications of data collected.

Threats

- Increase in severity of claims arising out of collisions but decrease in frequency (product liability).
- Cyber security and data protection.
- Reduction in losses hence reduction in insurance premiums.
- Risk sharing and pooling by manufacturers leading to a review of terms and conditions of trading.
- Levels of regulation in differing jurisdictions.
- Need for common infrastructure/architecture of support systems and the role of local (and national) government in supporting/adopting these in conjunction with private sector suppliers.

[2] IEEE, September 2012: http://www.ieee.org/about/news/2012/5september_2_2012.html

[3] Morgan Stanley, October 2012: http://www.businessinsider.com/morgan-stanley-autonomous-cars-trillion-dollars-2014-9?IR=T

[4] "Self-driving cars: The next revolution". kpmg.com. 5 September 2013. Retrieved 5 March 2015.

Preliminary model of the change of personal risk over time

The following preliminary model shows the impact of the emerging Advanced Driver Assistance Systems (ADAS) and collision avoidance technologies on risk and the changing nature of this. Figure 4 below shows a very significant reduction in personal risk over the next 30 years.

Figure 5 shows a preliminary model of the increase of product liability insurance shows how we expect an increase in liability taken by the vehicle manufacturer over the next 30 years as the vehicle embedded intelligence takes more and more of the risk exposure. Figure 6 illustrates the preliminary model showing the time taken for each new 'level' of autonomous capability to

Figure 4: Preliminary model of the increase of product liability insurance

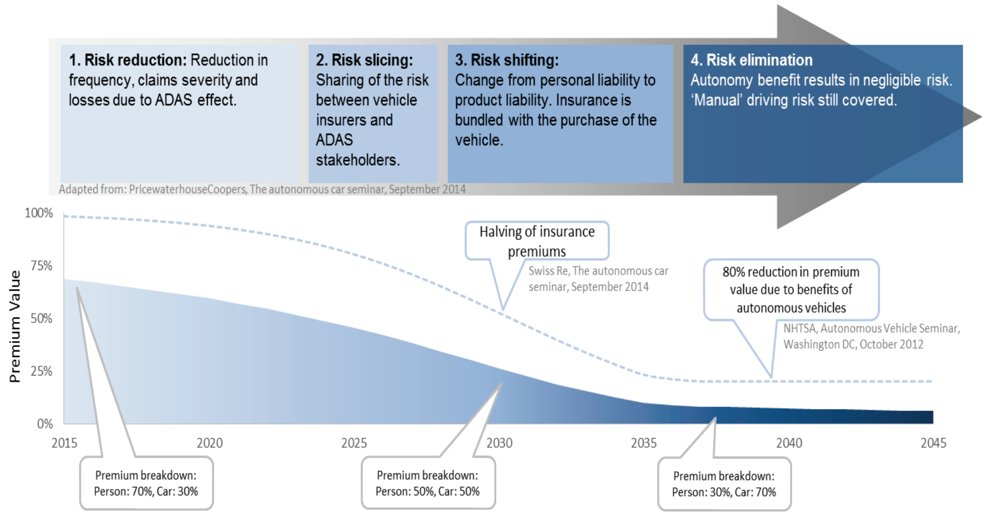


Figure 5: Preliminary model of the increase in product liability insurance over time

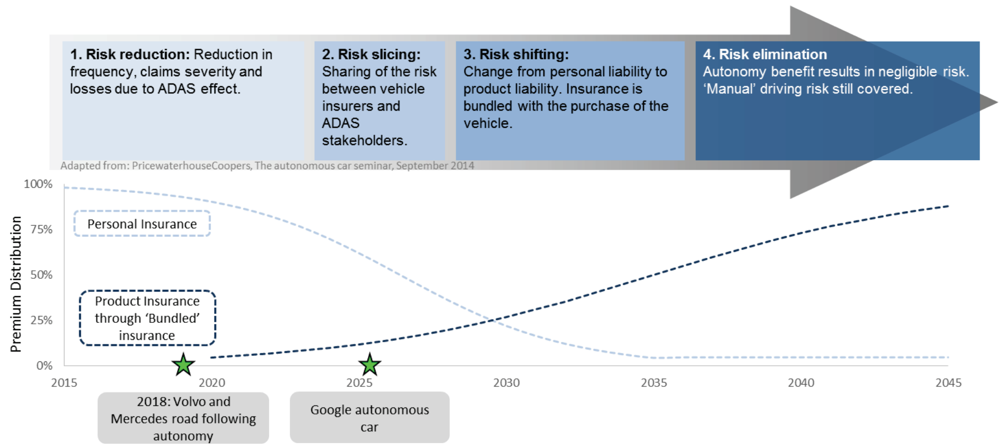
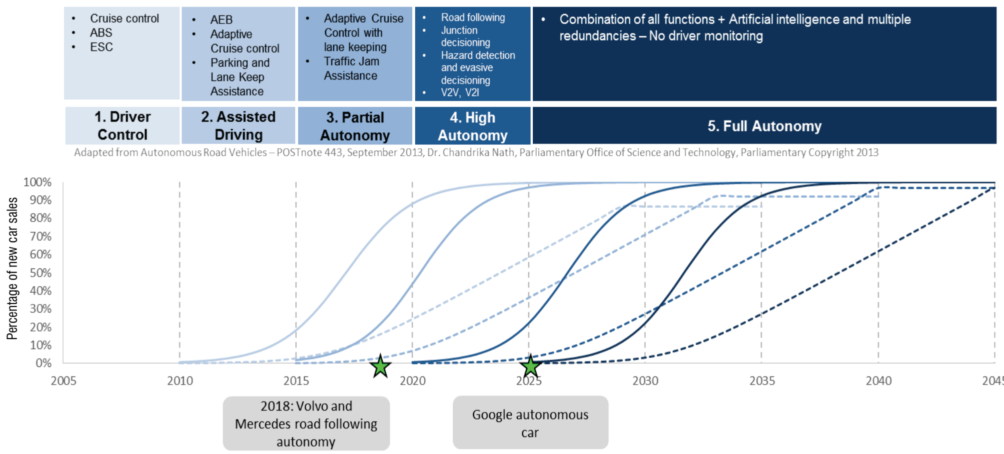


Figure 6: Preliminary model of the development of the autonomous fleet



penetrate the fleet. In the model, each 'level' takes approximately 15 years, so the end state of 100% of new car sales, so this would not occur until about 2040.

Conclusions

The introduction of increasing levels of automation can be considered in 2 categories: the near future (next 5 years) and longer term (2020–2040). These present different challenges. In the near term there will be gradual introduction of automation leading to vehicles of all types sharing the same road space. The risks associated with this are therefore higher in the near term and it is likely that the regulatory framework will adapt slowly to mirror the requirements "on the ground".

As the models above demonstrate, as vehicles become more fully automated, the risks of collisions diminish with a transference of risk from the driver/user to the vehicle itself and associated product liabilities.

The way in which cars are used will likely change – from individual ownership to shared ownership or car service schemes. There will remain different systems and therefore types or use of cars in various locations. The urban model will look very different to that on rural roads and from differ probably from country to country. At this stage, the regulatory framework will need substantial amendment.

The UK government is keen to get ahead and there are significant opportunities for those businesses who react earliest.

If you have any questions or comments about this Thinkpiece, please contact us: thinkpiece@cii.co.uk

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Andrew Miller has executive responsibility at Thatcham Research for the engineering aspects of the centre's work to research and promote vehicle best-practice engineering in vehicle safety, vehicle telematics, security and vehicle repair; working closely with vehicle manufacturers, UK and European Government, NGOs, insurance industry and other trade bodies to ensure that Thatcham's long term research and influence agenda is successful. Andrew is President and Chairman of the Board of Euro NCAP, is a Steering Committee member of RCAR, is a Council Member of the Road Safety Foundation, and is a member of the Society of Automotive Engineers and of the Institute of Directors.

Thatcham Research is the motor insurers' automotive research centre. Established by the motor insurance industry in 1969, the centre's main aim is to contain or reduce the cost of motor insurance claims whilst maintaining safety standards. It still occupies its unique position as the UK's only 'not for profit' insurer funded research centre. In addition to its original aims, the centre now plays a much wider role in the latest vehicle technology research, spanning safety, security and repair. Whilst the majority of Thatcham's work is funded by a levy on its over 30-strong insurers membership, the centre also generates its own revenue providing a unique range of products and services primarily to the motor repair industry, contributing to an annual turnover of around £15 million.Thatcham is a founder member of the international Research Council for Automobile Repairs (RCAR); and has also been a member of the European New Car Assessment Programme (Euro NCAP) since 2004.
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