LOSS SCENARIOS FOR INSURED AUTOMATED VEHICLES AND THE IMPACT ON MOTOR INSURERS

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August 2019

SCOR
The Art & Science of Risk

INTRODUCTION

Automated vehicles (AV) are already a reality, and are expected to influence not just the automobile industry but a number of stakeholders. For example, social & human sciences are researching – inter alia - interactions between humans and machines, while legal sciences are focussing on the allocation of liability and rights in terms of access to data and information, in line with the relevant data protection regulations[1]. For the insurance industry, and especially for the motor segment, automated vehicles will permanently reshape the business field. By eradicating human-error, which is the main cause of vehicle accidents[2], the existing literature expects accidents to become less frequent, which will in turn lead to a decrease in required motor risk premiums. In addition, the characteristics of known losses are expected to change, with new loss scenarios occurring due to the increasing complexity and interconnectivity of cars.

This article addresses future automated vehicle motor claims that could affect both primary insurers and reinsurers, from an underwriting, claims and risk management perspective. As well as transforming existing types of losses, automated vehicles may lead to new loss scenarios and new types of motor losses. Although these new scenarios are mainly triggered by faulty designs, primary motor insurers may initially be obliged to compensate claims where domestic law prescribes strict liability of the owner or a similar regulation - a development that can already be seen in German, British and South Korean legislation. For insurers, therefore, these new types of losses may significantly change the anticipated loss burden for motor business. This would force both primary insurers and reinsurers to reassess their motor insurance risk appetite.

Although the key assumptions described in the following can of course be transferred to other markets, the country-specific characteristics of each market may influence the weighting and importance of these assumptions.

The automation of vehicles

The technological progress of AV is advancing rapidly, developing in a number of technological stages commonly referred to as levels of automation[3]. According to the Society of Automotive Engineers (SAE), the transformation of a conventional vehicle into an entirely automated vehicle will take place over six levels of automation, in which level 0 represents conventional vehicles and level 5 fully automated, or autonomous, vehicles. At the highest level of automation, the system is expected to optimally perform the dynamic driving task, providing the highest level of safety and surpassing human limitations. In Germany, level 2 automation is already available in most high-end vehicles, with steering, acceleration and braking performed by the system[4]. In 2017, Audi was the first Original Equipment Manufacturer (OEM) to introduce level 3 automation with the "Audi AI traffic jam pilot", which is only designed for certain use-cases, i.e. traffic jams[5]. More complex driving tasks in other use-cases or situations, which are also referred to as Operational Design Domains (ODD), are performed in level 4 automation. At the

1) Taeihagh, A. and H.S.M. Lim, Governing autonomous vehicles: emerging responses for safety, liability, privacy, cybersecurity, and industry risks. Transport Reviews, 2019. 39(1): p. 103-128.
2) European Commission, Saving Lives: Boosting Car Safety in the EU. REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL, 2016.
3) SAE, Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems-J3016.
Society of Automotive Engineers: On-Road Automated Vehicle Standards Committee; SAE Pub. Inc., Warrendale, PA, USA, 2013.
4) DAT, DAT Report 2017. 2017.
5) Audi Media Center. Automated driving at a new level: the Audi AI traffic jam pilot. 2017 Accessed: 15.05.2018; Available from:
https://www.audi-mediacenter.com/en/press-releases/automated-driving-at-a-new-level-the-audi-ai-traffic-jam-pilot-9300

present time, this level of automation only exists within prototypes, which are tested under strict observation and are not yet available to the public. However, the first commercial usage of this automation level, which still requires a human backup driver, was announced in December 2018 by Waymo[6]. Level 5 automation does not exist at the present time as it is defined as completely driverless, with no driving equipment.

SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You are driving whenever these driver support features are engaged - even if your feet are off the pedals and you are not steering			You are not driving when these automated driving are engaged - even if you are seated in «the driver's seat'		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			**These are automated driving features**		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/ acceleration support to the driver	These features provide steering AND brake/ acceleration support to the driver	These feature can drive the vehicle under limited conditions and will operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering OR • adaptive cruise control	• lane centering AND • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/ steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

Figure 1: Levels of automation according to SAE[7]

6) Waymo Team. Riding with Waymo One today. 2018 Accessed: 01.03.2019; Available from: https://medium.com/waymo/riding-with-waymo-one-today-9ac8164c5c0e.
7) SAE International. SAE International Releases Updated Visual Chart for Its "Levels of Driving Automation" Standard for Self-Driving Vehicles. 2018 Accessed: 11.03.2019; Available from: https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-%E2%80%9Clevels-of-driving-automation%E2%80%9D-standard-for-self-driving-vehicles.

It is commonly assumed that the increased safety level provided by automated vehicles will decrease the frequency of accidents, because of the progressive removal of the human as the driver – human error being the main cause of accidents. Starting at automation level 3, the onboard systems will perform specific driving-mode tasks in pre-defined use-cases, these tasks becoming more complex and comprehensive in automation levels 4 and 5. Because the system monitors the driving environment and executes driving commands on its own, the human driver has a purely supervisory function, intervening only when the systems prompt them to do so or when they perceive a need to act.

The nature and extent of claims arising from automated vehicles are not yet known, but will permanently change the underlying loss burden for both primary insurers and reinsurers until full technical maturity is reached. In addition to the transformation of existing types of claims, AV will create new loss scenarios and therefore impact the required risk premiums for both Motor Third Party-Liability (MTPL) and Motor Own Damage (MOD) policies.

What do you think?

Traditional motor underwriting focuses on the human driver as the major risk exposure. However, starting at automation level 4, the onboard systems will monitor the driving environment and perform the dynamic driving task. Is traditional motor underwriting for automation levels 4 & 5 still adequate?

Single motor insurance claims: today and tomorrow

The motor insurance business is one of the largest non-life business lines in Europe, covering mainly MTPL and MOD. In general, MTPL policies compensate justified third-party claims in respect of bodily injury, property damage and consequential financial losses up to a pre-defined indemnity limit. Conversely, MOD policies insure the vehicle as such up to its market value, thus reimbursing the vehicle owner. In Germany, these MOD policies can either consist of partially comprehensive cover, in which the vehicle is insured against perils such as glass breakage, theft (partial or total), natural catastrophes (storm, hail, lightning, etc.), or fully comprehensive cover, where the aforementioned coverage is extended for example by own damage caused by self-inflicted accidents and malicious damage. Figure 2 illustrates the single insured motor losses for German insurers between 2005 and 2016. Sorted by average claims costs, which are displayed on the x-axis, the secondary y-axis displays the cumulative severity and frequency of these claims. As we can see from the graph, 50% of the accumulated observed claims account for just 17.81% of the accumulated observed frequency, underscoring the fact that this line of business is characterised by a high-frequency and low-severity loss pattern. This observation is also true for other markets .

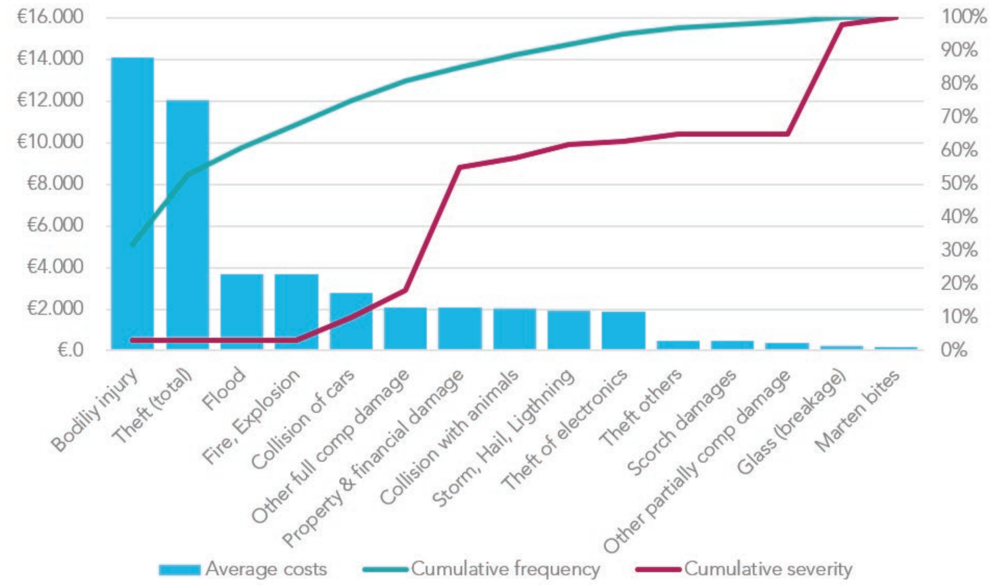

Figure 2: Average Costs, Cumulative Frequency and Cumulative Severity of single insured motor losses for German insurers; own evaluation
Source: German Insurance Association (GDV)

There are two exceptions to this high-frequency and low-severity loss pattern. The first: bodily injury claims emanating from MTPL losses that are potentially exposed to financial long tail-risks. The financial tail risk is due to the fact that MTPL policies compensate severe bodily injuries or physical impairments in a third party, which can be settled either via a lump sum or through annuity payments. Depending on factors like age, occupancy, etc., these settlements can have a significant claims dimension for both primary motor insurers and their reinsurers. However, these large MTPL claims are attributed to single motor losses in the sense that only one vehicle is the causative party, generally damaging only one other vehicle and its occupants. Therefore, these losses are mainly[8] independent from each other and are rebalanced in a homogenous and sufficiently large risk portfolio over time, assuming that a disproportionately high number of original insureds are not affected in one business year and that these losses do not occur to an extreme extent every year[9]. Natural catastrophes, which are usually characterized by low-frequency and high-severity loss events, are the other exception to the high-frequency and low-severity loss pattern. Nat cat events are covered by MOD, i.e. partially comprehensive cover in which individual risks are exposed to the same peril at the same time in the same area, and hence are positively correlated. Although the maximum indemnity for an individual insured vehicle is limited to its market value, nat cat events affect many insured vehicles at once, thus leading to high accumulated loss amounts. Due to the increasing average values of automated vehicles, and their complexity, the severity of existing nat cat events may increase. There is already an observable trend in that the repair costs for vehicles equipped with the latest technology are more expensive compared to older vehicles[10]. The main drivers of this inflation are the quality of damaged parts and additional labour costs .

8) N.B. Notable examples for positively correlated losses are faulty tires and brakes.
9) Farny, D., Versicherungsbetriebslehre. 2011: Verlag Versicherungswirtsch.
10) Deloitte. 2019 Global Automotive Consumer Study. 2019 Accessed: 06.05.2019; Available from:
https://www2.deloitte.com/us/en/pages/manufacturing/articles/automotive-trends-millennials-consumer-study.html

Figure 3: Average cost to replace a windscreen with & without "Advanced Driving and Assistant Systems" (ADAS); own evaluation
Source: AXA UK[11]

Latent nat cat events and the increase in expected loss severity will make it more difficult for motor insurers to balance nat cat claims within a business year, particularly within a regional limited risk portfolio. Therefore, primary insurers must either balance these claims within a sufficiently large portfolio over time, or transfer the risk to an external party such as a reinsurer.

For conventional vehicles (i.e. automation level 0-1), over 90% of motor accidents are due to an error on the part of the human driver, making the human driver the major causative party in the event of an accident[12]. Accidents can also be caused by the vehicle itself (e.g. tyres/wheels) or the environment (e.g. slippery roads)[13]. Unlike "conventional" vehicles, automated vehicles involve new elements and parties in their production and use, such as software programmes, internet providers and live data providers. A mistake or fault by one of these new elements or parties could result in new sources of failure, thus creating new loss scenarios. As summarized in Figure 4, the risk landscape surrounding AV becomes more complex as more possible crash causes are created.

11) Williams, D. Driverless cars - the future of road transport and the implications for insurance. 2018 Accessed: 02.05.2019; Available from: https://www.cii.co.uk/learning-index/articles/driverless-cars-the-future-of-road-transport-and-the-implications-for-insurance/68230.
12) European Commission, Saving Lives: Boosting Car Safety in the EU. REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL, 2016.
13) Sigh, S., Critical reasons for crashes investigated in the National Motor Vehicle Crash Causation Survey. 2018, National Highway Traffic Safety Administration: Washington, DC.

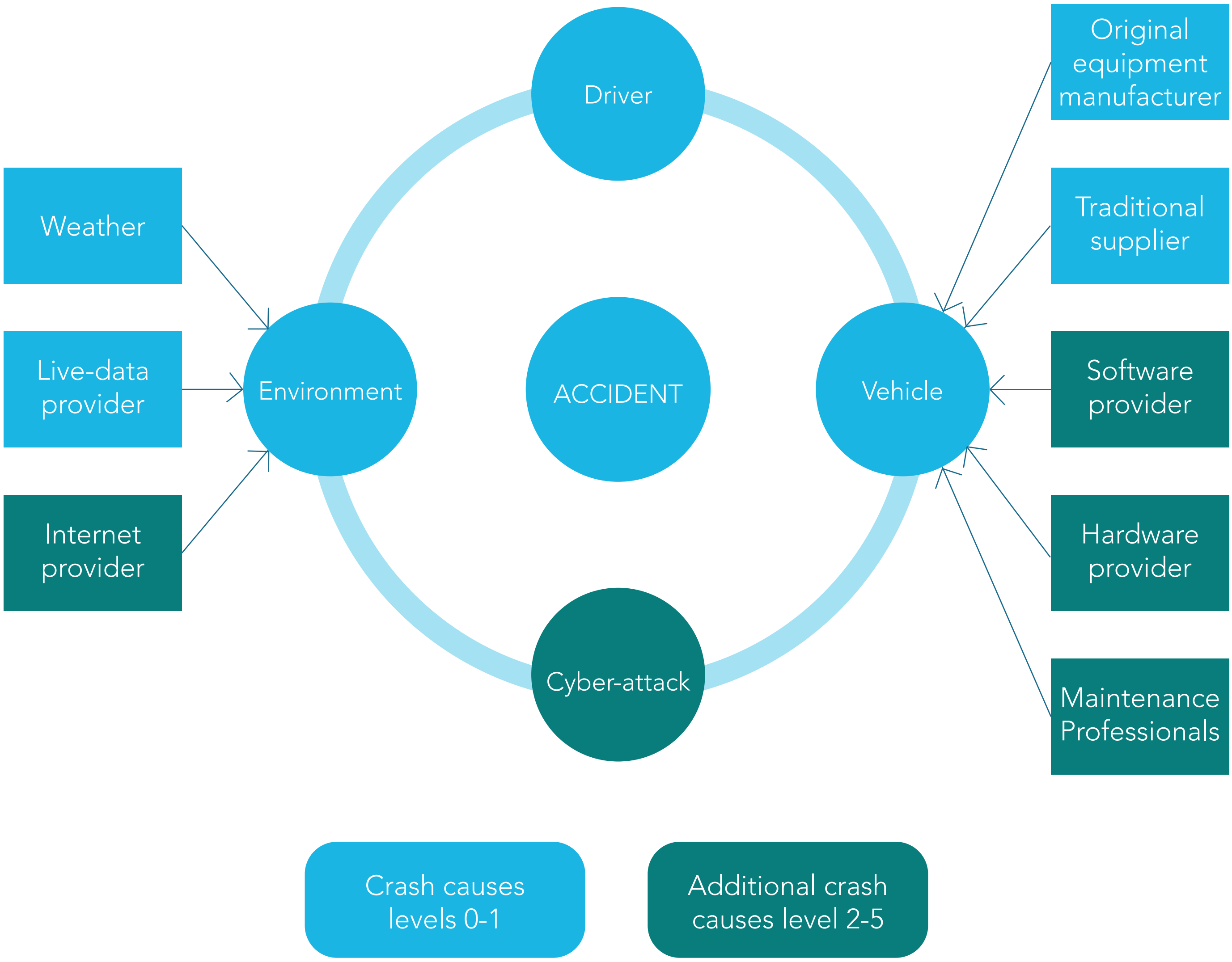

Figure 4: Crash causes for automation levels 0 - 5; own evaluation
Source: National Highway Traffic Safety Administration (NHTSA)[14], SCOR

These new losses can often be attributed to faulty product design and should therefore be compensated according to domestic product liability law. AVs are already governed in certain jurisdictions like Germany, the UK and South Korea. All legal regimes have taken the same approach so far, i.e. the driver is still liable in terms of liability for presumed fault, and the vehicle owner/keeper is liable in the sense of strict liability. If an accident is caused by the onboard automated features, the primary motor insurer must compensate the damaged parties in the first instance, and has the right to take recourse against the producer of the faulty product if the provisions of the domestic product liability law are fulfilled. Considering the exemplary character of Germany, the UK and South Korea, we may assume that other liability regimes will adopt the strict liability approach to ensure victim protection. In view of this, and of the AV accidents that have already taken place, this emerging risk needs effective risk management. As shown in the hereafter table, new motor loss scenarios emanating purely from the characteristics of AV are compensated by MTPL policies, if the domestic legislation of the country concerned prescribes strict liability of the vehicle owner.

14) Sigh, S., Critical reasons for crashes investigated in the National Motor Vehicle Crash Causation Survey. 2018, National Highway Traffic Safety Administration: Washington, DC.

Loss scenarios for insured automated vehicles & the impact on motor insurers

No	Scenario	Obligation to compensate	Source of failure	Causative party	Real-life example
1	Several automated features are active at the same time. While the car turns left, the driver activates the headlamps and wipers at the same time. The car suddenly accelerates and crashes into an obstacle.	Yes	The interaction of actual independent components results in an unforeseeable driving command ("trial and error").	Manufacturer (recourse possible)	Not yet known
2	Automated vehicles equipped with a certain supplier's device crash into standing objects.	Yes	Faultily designed device does not capture the driving environment correctly, leading to a false system decision.	Device supplier (recourse possible)	Tesla Accidents January, May & August 2018; minor bodily injuries[15]
3	Vehicle in automated mode runs over pedestrians without slowing down or braking.	Yes	Software failure does not capture obstacles on the road correctly. Pedestrians are hit because they are categorised as leaves ("false-positives").	Software programmers (recourse possible)	Uber Crash 18th March 2018; one fatality[16]
4	While driving in a foreign country, network connection problems do not allow a stable connection to the cloud. The automated vehicle veers severely to the right, hitting a crash attenuator.	Yes	False actuating commands are executed as systems do not receive required information in time.	Internet provider (recourse possible)	Tesla Crash 26th May 2018; property damage only[17]
5	Vehicle's GPS data is not transmitted and processed. Automated vehicle swerves into the right-hand side of the lane hitting a standing car.	Yes	False actuating commands are executed as systems do not receive required information in time.	Live data provider (recourse possible)	Tesla GPS location stuck; no accidents so far[18]
6	System requires the human driver to resume control over the vehicle and sends signals accordingly. Driver ignores these and is distracted by mobile phone. Vehicle crashes into lane divider.	Yes	Over reliance and trust in systems in combination with carelessness of the human driver.	Human driver (recourse possible)	Tesla-Crash 23rd March 2018; one fatality[19]
7	During annual maintenance check-up, speed limiter is removed without permission. Due to the missing speed limiter, vehicle accelerates too fast and crashes into another vehicle.	Yes	Missing software files lead to false actuating commands.	Maintenance professionals (recourse possible)	Tesla Crash 8th May 2018; two fatalities[20]
8	Fleet operator fails to install latest update. While lane change system is active, vehicle crashes into white truck, which could have been avoided with specific update.	Yes	Breach of duty of care because of the fleet operator's (gross) negligence.	Fleet operator (recourse possible)	Not yet known
9	While on the road, hackers use the unsecured infotainment system of the automated vehicle to upload malware blocking driving commands. Vehicle crashes into a standing obstacle.	Yes	Interconnectivity of cars allows for exploitation of system's weak spot and possible spread of malware.	Hacker (recourse possible - if party is known)	Tesla September 2016; test-hack to research security vulnerabilities[21]

Figure 5: Possible loss scenarios due to AV-specific characteristics (exemplary list); own evaluation

15) National Transportation Safety Board (NTSB). Preliminary Report Highway: HWY18MH010. 2018
16) Gulezian, L.A. Millbrae driver says Tesla Model 3 was in Autopilot when it crashed in Greece. 2018
17) Tesla Motor Club (TMC). GPS stuck/ location not updating (Solved now). 2018
18) National Transportation Safety Board (NTSB). Preliminary Report Highway: HWY18FH011. 2018
19) Schlein, Z. Tesla Hit with Negligence Suit Following Fatal Car Crash in Fort Lauderdale. 2019
20) Keen Security Lab of Tencent. Car Hacking Research: Remote Attack Tesla Motors. 2016
21) Deloitte. 2019 Global Automotive Consumer Study. 2019

The loss scenarios shown on previous page are mainly attributed to technological defects in a component or the onboard systems. However, accidents may also happen if the effectiveness of safety features is limited, for example due to unstable network connections or slow transmission of GPS data. As these circumstances do not necessarily represent a defect in a component or system, it is arguable whether the motor insurer would have recourse against the producer based on the corresponding domestic product liability law. Nonetheless, for motor insurers, claims arising from this type of system "underperformance" represent a new type of loss, for which the owner of an automated vehicle can be held liable and which are compensated by MTPL policies. Due to the changing risk landscape surrounding automated vehicles, the time horizon for identifying the guilty parties and asserting legal claims against them could be very long. Moreover, the insurer would need to have corresponding expertise, for example to analyse the black boxes of the faulty automated vehicle, which would increase the administrative costs involved. This means that the capital requirements of motor insurers covering automated vehicles may not be reduced by all that much in the mid-term, because they will need to hold available capital to pay for such claims until standardised and fast-recourse mechanisms are established. The time horizon for establishing these mechanisms depends, among other things, on the consumer's acceptance of the risk. As Figure 6 below shows, acceptance of AVs is already slightly above 50% in Germany, the UK and South Korea.

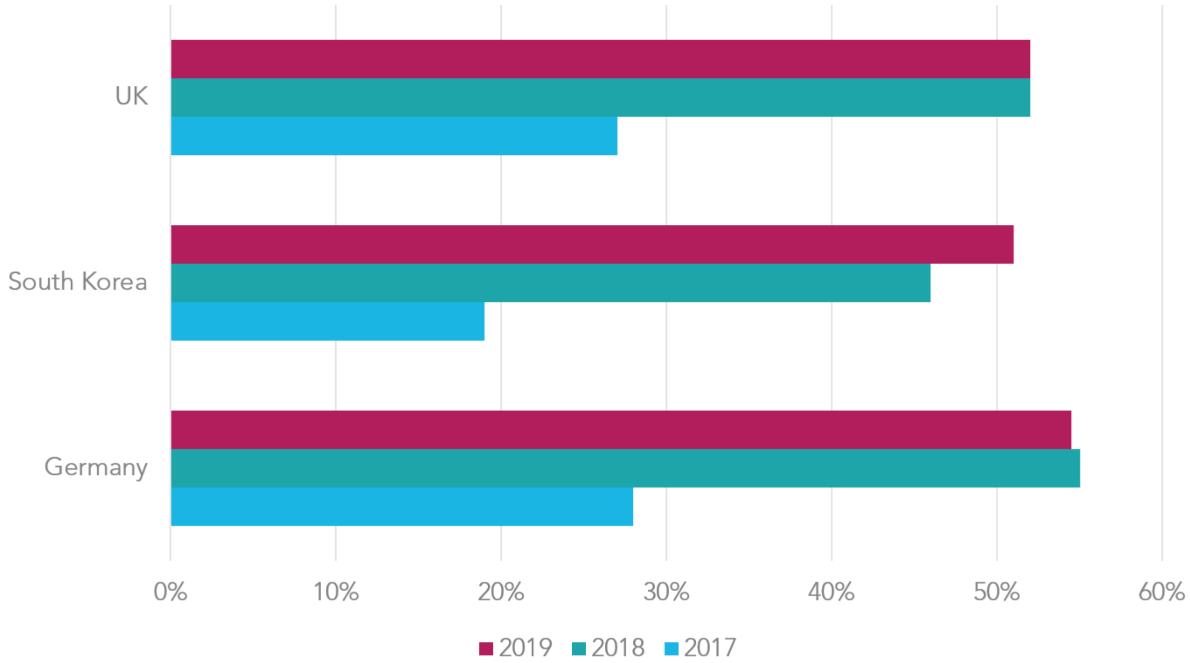

Figure 6: Percentage of consumers who believe that AVs will be safe; own evaluation
Source: Deloitte[22]

The interconnectivity and complexity of cars may create new causes of damage such as single points of failure and systemic malfunctions, leading in turn to repeated erroneous command executions and creating possible serial accident losses[23]. Because there is no reference data available, the frequency and severity of these new types of claim events cannot be clearly defined at present. Nevertheless, they may become the subject of further studies in the future.

22) Deloitte. 2019 Global Automotive Consumer Study. 2019 Accessed: 06.05.2019;
Available from: https://www2.deloitte.com/us/en/pages/manufacturing/articles/automotive-trends-millennials-consumer-study.html.
23) cf. SCOR Technical Newsletter No.42 "Intelligent machines: Risk and Opportunities for (Re)Insurance"

CONCLUSION

The technological advance of automated vehicles is an ongoing process, which will ultimately result in fully autonomous driving where the system constantly monitors the driving environment and performs all aspects of the dynamic driving task. For the insurance industry, this gradual shift from the human driver to the system as the driver will significantly disrupt the motor insurance sector. The shift is made possible by the onboard systems, which involve new parties in the whole production and use process. However, this involvement of new parties creates new possible sources of failure, and hence new loss scenarios. In a strict-liability regime like Germany's, primary motor insurance is triggered first, followed by a subrogation claim against the product liability policy. However, these single losses also have the potential to create accumulation events, for example due to system malfunctions. Therefore, automated vehicles could potentially create new accumulation events as well as new single motor losses.

In conclusion, automated vehicles do not represent the end of motor insurance. Rather, losses will evolve, and the risk landscape will be permanently changed, forcing both primary insurers and reinsurers to adapt to the transformation. Primary insurers must consider their risk appetite and whether their existing reinsurance coverage is still sufficient to cover the capital requirements arising from the advent of automated vehicles. For their part, reinsurers must adapt to this transformation by amending their motor reinsurance wordings to incorporate these new types of losses.

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