

Evaluation of the need for function and efficiency testing of advanced driver-assistance systems (ADAS)

as part of the periodical technical inspection, based on a meta-analysis



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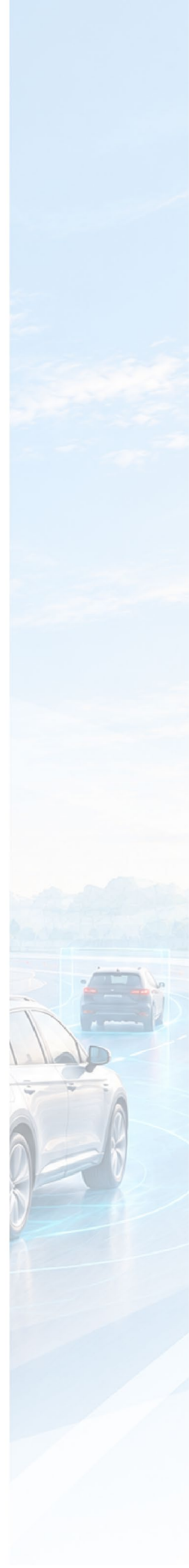


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1 Executive Summary

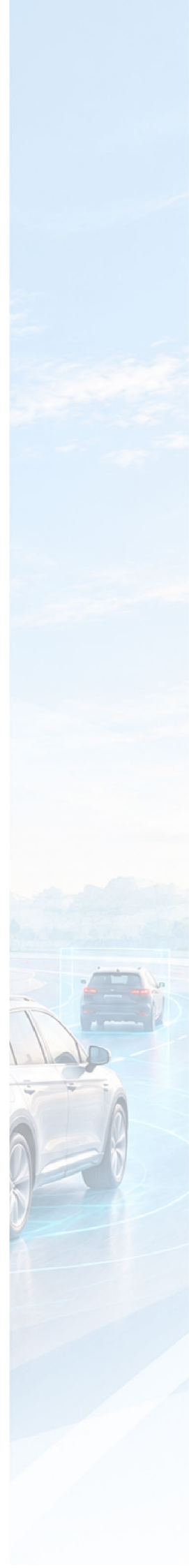
Personal mobility is a key aspect of social participation. Most of the travel is still carried out using manually driven passenger cars. Despite the many advantages of this form of mobility, it also leads to risks to road safety. Every year, the Member States of the European Union record around 20,000 road deaths and a far higher number of serious injuries.

To realise the vision of accident-free mobility, the European legislator has made the implementation of safety-related advanced driver-assistance systems mandatory for new vehicles. These systems have considerable potential to significantly improve road safety. Scientific analyses show that the use of driver assistance systems can significantly reduce the number of people killed and injured in road traffic accidents. With the increasing market penetration of these systems and further improvements in their performance, disproportionately large improvements in road safety are expected in the coming years.

To realise the full safety potential of ADAS in real-world vehicle operation throughout their entire service life, it is essential that they function as intended. Unnoticed functional impairments caused by damage, ageing and wear and tear, as well as by repairs that have not been carried out or have been carried out incorrectly, or by faulty calibrations, reduce the effectiveness of the systems in operation. Even though it is currently difficult to quantify ADAS faults in the field with any precision, studies and analyses show that a significant number of vehicles do not function as intended.

The use of ADAS leads to a significant increase in vehicle complexity, placing high demands on garages and insurers, as well as on the periodical technical inspection (PTI). Even today, the fitment and condition of the systems are checked manually, visually and electronically. This approach enables numerous defects to be identified and safety risks to be minimised; however, the detection rate of current testing procedures is limited. To significantly increase the depth of testing and to ensure the functional reliability of modern vehicles in the long term, it is essential to expand the PTI to include a dedicated function and efficiency test.

This paper demonstrates the need to extend the general roadworthiness test to include a function and efficiency test of advanced driver-assistance systems. The argument is based on a meta-analysis of existing research and studies, which examines in detail the safety potential of driver-assistance systems, known instances of failure in the field and possible testing approaches.



2 The contribution of driver assistance systems to road safety

Road safety objectives

Most of the private transport in Germany and many other countries is currently provided by manually driven passenger cars. Despite a range of new mobility solutions and concepts that are creating greater diversity in transport, particularly in urban areas, the passenger car remains the most important type of transport for passenger travel [1]. In recent years, various developments in vehicle propulsion systems and the integration of ADAS have brought lasting changes to vehicles. In addition to improvements in environmental and climate protection, the focus is particularly on enhancing road safety.

Through the 'Pakt für Verkehrssicherheit', Germany's key objective is to reduce the number of road deaths by 40 per cent by 2030 compared with 2021. In addition, the number of people seriously injured in road traffic accidents is to be significantly reduced [2].

European road safety targets stipulate that the number of people killed in road traffic accidents should be reduced to half by 2030 compared with 2019. By 2050, the aim is to have zero road deaths.

The United Nations also reaffirmed the Vision Zero target in the 'Stockholm Declaration', which aims to reduce the number of road traffic fatalities and serious injuries to zero by 2050. In specific areas of action, measures such as investment in safe infrastructure and the promotion of safe vehicle technologies are recommended [3].

Although the European Court of Auditors considers it unlikely that these targets will be fully achieved, ADAS will make an increasing contribution to preventing road deaths and serious injuries during the next years [4].

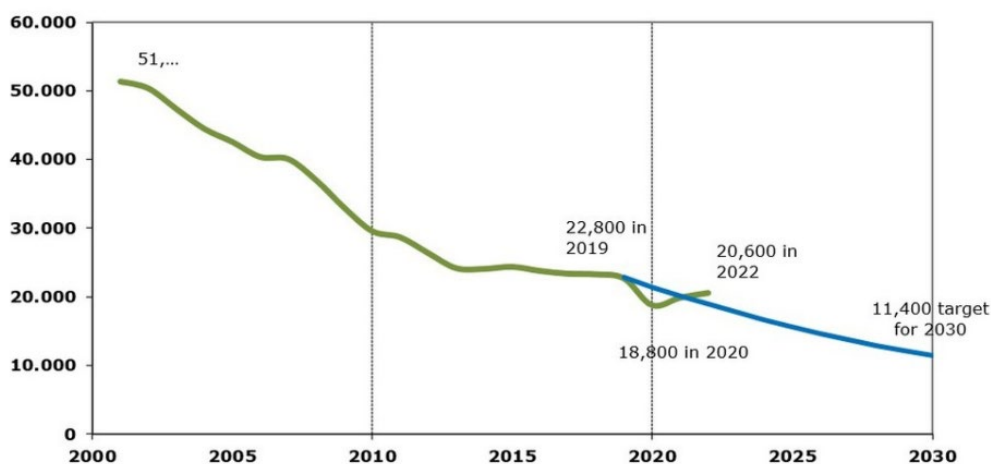


Figure 1: Number of road deaths in the EU (green), EU objective for 2030 [5]

Under Regulation (EU) 2019/2144 (General Safety Regulation II, GSR II), key safety-related driver assistance systems have been made mandatory from July 2022 for newly type-approved vehicles and from July 2024 for all newly registered vehicles [6]. Market penetration of these systems is expected to reach approximately 50% by 2030 [7]. Furthermore, minimum requirements for these systems are defined in the relevant regulations and standards (e.g. UNECE R 152 [8]). It can be assumed that the actual implementation of the systems will, partly, exceed these minimum requirements.



Relevant systems in the context of this analysis are:

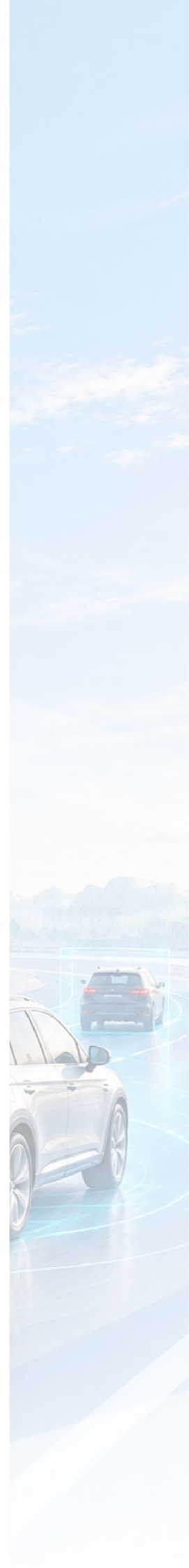
- Automatic Emergency Braking (AEB)
- Intelligent Speed Assistance (ISA)
- Emergency Lane Keeping Assist (ELK)
- Reversing assistant

Although road safety in the European Union has improved in recent years thanks to a series of measures and developments, approximately 20,000 people currently die each year because of road traffic accidents [9]. The number of seriously injured people is estimated to be over 100,000 [10]. 2,814 people lost their lives in road traffic accidents in Germany in 2025. 48,400 people were seriously injured [11]. ADAS have great potential to reduce these figures, particularly if their functionality also considers interaction with vulnerable road users. [12] estimates that, over a period of 15 years following mandatory introduction, there will be approximately 25,000 fewer road deaths and 140,000 fewer serious injuries than there would be without these systems. It should be taken into account that market penetration will continue to rise over this period and that, as a result, the reduction in the number of road deaths and serious injuries will not be linear but will increase disproportionately.

Effectiveness of ADAS

Driver assistance systems are developed and validated under defined conditions using specific scenarios, both through simulation and during real-world driving testing. As part of the type-approval process, the systems' characteristics are tested for compliance with statutory minimum requirements and standards. As conditions in real-world traffic can vary greatly, the actual effectiveness of the systems is lower than the theoretically possible level. It must also be considered that some systems warn the driver but do not intervene in the vehicle's control systems. These warnings, such as those from a reversing assistant, can be overlooked or ignored, resulting in reduced effectiveness. Despite these limitations, ADAS are already leading to significant reductions in road traffic accidents and the related personal injuries.

[13] reports a 50% reduction in accidents for AEB systems in the case of front-to-rear collisions (56% for accidents resulting in injuries). Other sources attest to an effectiveness of 49% [14] or 45% (58% for accidents involving injuries) [15] for AEB systems, also for rear-end collisions. It should be noted that these figures are not based on the total number of all accidents. As the analysis is limited to specific types and conditions of accidents, the impact on real-world accident patterns is only partially reflected; nevertheless, the systems' suitability for reducing accidents is demonstrated. Although quantitative extrapolation to other countries is only possible to a limited extent due to the specific characteristics of US traffic on which this data is based, the qualitative correlations are transferable to other countries and regions. A study from the UK [16] confirms that AEB systems are the most effective of all driver assistance systems, achieving a significant reduction in accidents in the categories of junctions (28%), rear-end collisions (27.7%) and accidents involving pedestrians (28.4%), provided the entire vehicle fleet is fully equipped with these systems.



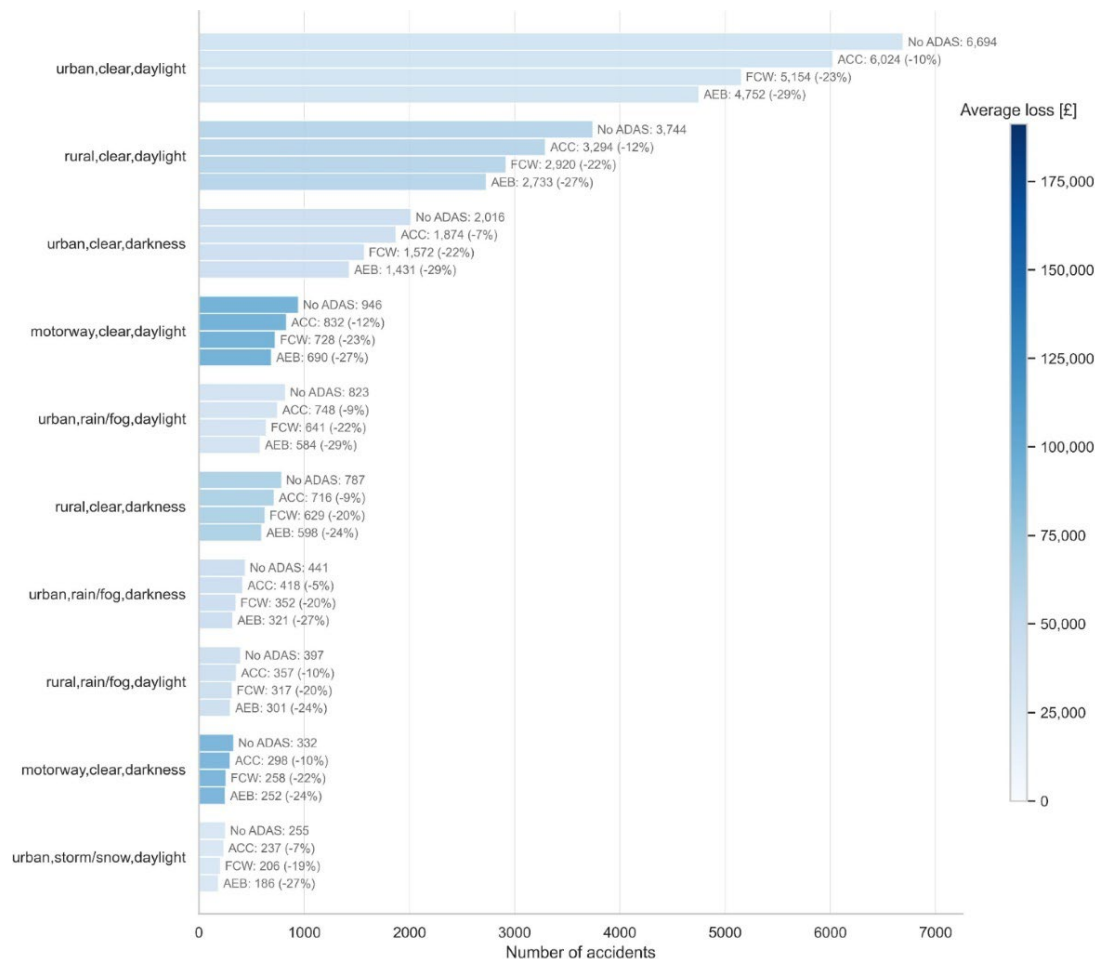
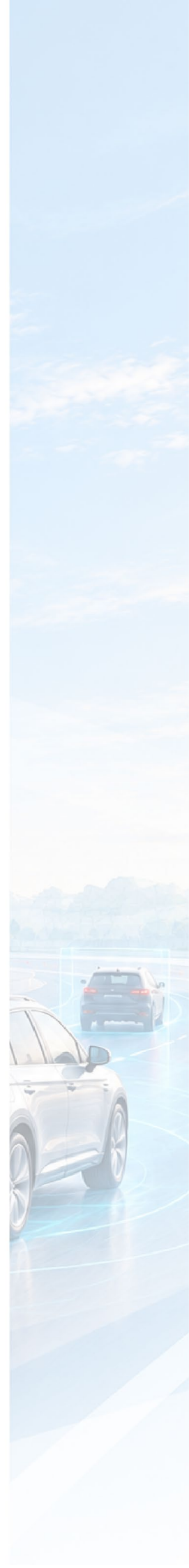


Figure 2: Potential reduction in rear-end collisions through ADAS, 10 most common accident scenarios [16]

The potential for accident prevention through systems designed to monitor traffic behind the vehicle and to prevent lane departure is estimated to be lower in the studies available. [13] states that a lane departure warning system is 21% effective in preventing single-vehicle accidents resulting in personal injury. The same study finds a 23% reduction in lane-change accidents resulting in injuries when a blind-spot warning system is fitted. It should also be noted here that, when considering all road traffic accidents, the actual effectiveness is significantly lower.

ADAS functionality over the vehicle's lifetime

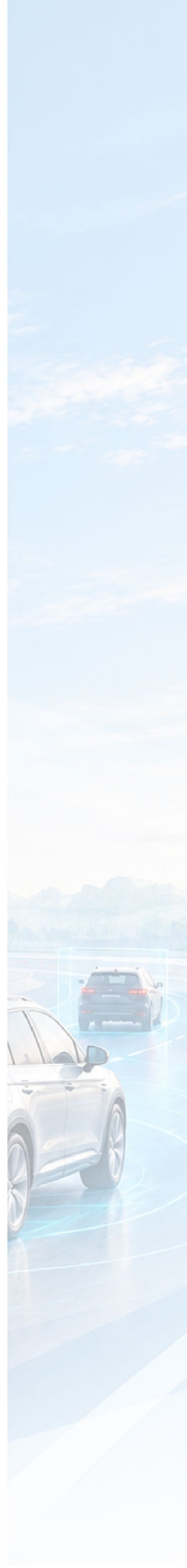
A key prerequisite for the correct functioning of ADAS is the perception of the vehicle's surroundings by sensors installed in the vehicle for this purpose. Only when the systems function as intended their full potential for accident prevention and the mitigation of accident consequences can be realised. Like any other system in the vehicle, driver assistance systems can suffer a degradation in performance due to damage, improper repairs, tampering or ageing. Conditions may also arise that already lead to a significant reduction in performance, yet are not recognised as faults by the vehicle's diagnostic system and are not indicated to the driver [17], [18], [19], [20], [21], [22].



Based on the research and studies analysed as part of this meta-study, there is ample evidence of potential reduction in ADAS functions during operation. However, the sources considered do not allow conclusions to be drawn regarding the full range of faults that may occur during operation and their frequency in the field. The use of accident data to indirectly infer the nature and frequency of ADAS faults is also limited, as the way this data is collected means that no conclusion can be drawn regarding ADAS faults as a cause of accidents. In [23], the road safety potential of AEB systems was determined using simulations based on known accident scenarios. Due to the lack of actual data on the frequency of faults in the field, the confidence in the quantitative findings of this type of analysis remains limited, even if the methodological approach is correct.

Driver assistance systems enhance road safety and are an important tool for achieving the transport policy objectives of Germany and the European Union. During operation, functional impairments may occur which are often unnoticed by the driver and can only be partially detected using current PTI test methods.

Potential faults and their associated frequencies in motor vehicles cannot be precisely determined using currently available sources. The following chapter therefore demonstrates, through a detailed analysis of known faults and anomalies, that a significant number of vehicles with impaired ADAS functionality can be expected to be in operation.



3 Derivation of the need for extended testing based on known fault cases

In the following chapter, a qualitative overview of potential faults and their effects is provided through a detailed analysis of existing studies, investigations and other sources.

Research results on the functional impairment of ADAS caused by misaligned environmental sensors

Mechanical misalignment of the sensors required for correct environmental detection plays a significant role in the context of ADAS malfunctions. This misalignment can be detected by the on-board diagnostics system, and the driver can be alerted to the malfunction once a vehicle- and system-specific threshold is exceeded. It is possible to flag this as a defect during the PTI by using data from the on-board diagnostics system. If the misalignment is below the so-called misalignment threshold, the system tolerates it. However, existing studies show that even when misalignment falls within the tolerance range, a sometimes significant deterioration in performance occurs.

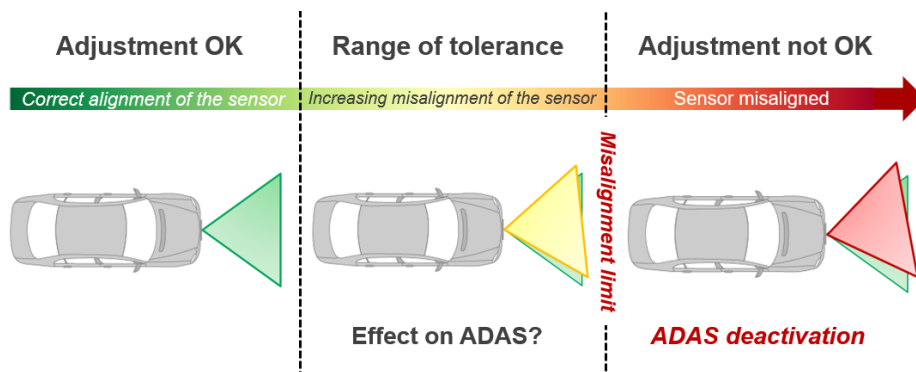


Figure 3: Sensor misalignments in vehicles [24]

In [19] DEKRA investigated the effects of camera misalignment on the functionality of the AEB using three test vehicles. Furthermore, the study examined the influence of rear radar misalignment – such as that which may occur following a minor parking collision – on the warnings issued by the blind spot assistant. In both cases, significant functional limitations occurred, even though the faults were not detected as such by the on-board diagnostics system. In the scenarios for the AEB investigation, collisions occurred with test targets that the system would have been able to avoid had it been correctly calibrated. The blind-spot assist warnings were also delayed, leading to an increased safety risk. Even prior to this investigation, the ErVast research project – in which DEKRA participated – had identified similar effects on the AEB of a test vehicle caused by manipulation of the front camera [21]. The adjustment angles of the front camera were correctly detected by the vehicle as part of a dynamic calibration. However, as these were within the tolerance limits, the self-diagnostic system did not flag any fault.

A white paper by Ascential Technologies [18] examines the impact of poor or faulty calibration of the front camera and front radar on a 2024 Nissan Altima. The results show a significant deterioration in performance, manifesting as collisions with the targets used, which were prevented in tests conducted with correct calibration. Furthermore, delayed warnings and system failures of the lane departure warning system were also observed due to incorrect or missing calibration of the front camera.





Figure 4: Vehicle collides with a vehicle target without braking (sensors misaligned, calibration missing), left; vehicle collides with a pedestrian dummy (actual condition after 12,900 miles, collision avoided following calibration), right [18]

In [24] FSD Fahrzeugsystemdaten GmbH and DEKRA present a comprehensive study of the impact of misalignment of radar and camera sensors on three test vehicles. The study examined both front and rear scenarios in which the sensors were misaligned individually as well as in combination. Various vehicle and occupant dummies were used for the scenarios, some of which were based on NCAP criteria. To draw well-founded conclusions about the functionality of the ADAS, the tests were conducted at low and medium speeds.

The results show measurable, negative effects on behaviour of the ADAS under consideration. Compared with test drives without sensor adjustment, vehicle-specific collisions (ACC and AEB), reduced time to collision (AEB), altered control behaviour (ACC), delayed warning times and missing warnings (AEB, BSM and SEW), as well as faulty warning sequences and steering corrections (LKA) were observed. All adjustments and manipulations to the vehicles were carried out within the tolerance limits of the vehicles' self-diagnostic systems. In addition, a run-in routine for 'self-calibration' of the system was performed prior to the test. The driver was not informed of any potential malfunctions of the ADAS. Figure 5 illustrates the test results for one of the vehicles examined.

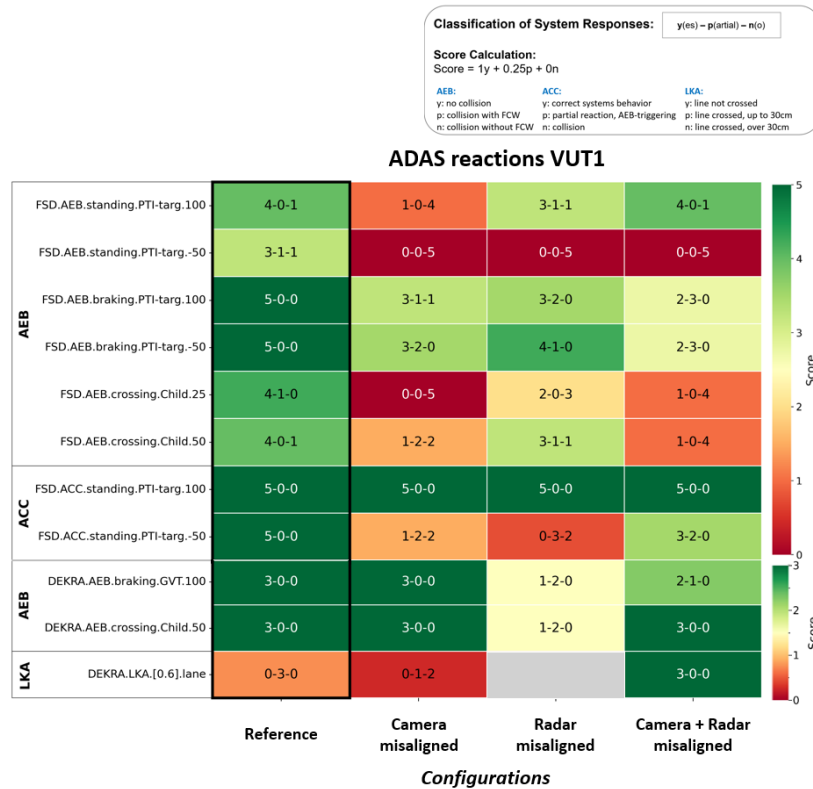


Figure 5: Performance degradation due to adjustment of the environmental sensors near the misalignment limit [24]



Effects similar to those caused by sensor misalignment can also result from modifications to the vehicle or its chassis. In [25] TRL investigated the influence of changes in vehicle height – caused by raising or lowering the vehicle – on ADAS functionality. The study concludes that changes to vehicle height also have a vehicle- and sensor-specific impact on ADAS functionality. Altering the height of the sensors also affects the detected distance to objects ahead. Calibration following suspension adjustment is necessary to ensure the correct functioning of the ADAS.

Impaired ADAS functionality due to faulty repairs and incorrect calibration

As result of an accident or a minor parking collision, a sensor may be misaligned. This can occur with radar sensors, which may be concealed behind bumpers or radomes, but are sometimes also fitted directly into the bumper. However, the repair work itself can also interfere with the radar sensors. In the study presented in [20], the impact of repairs to rear bumpers within the radar's field of view is examined. The application of body filler and subsequent painting in this area can lead to the detection of non-existent objects, sporadic system errors and reduced detection ranges. Furthermore, it is possible that objects may not be detected at all. The transmission properties of objects mounted in front of sensors must be taken into account as early as the vehicle development stage. The paint layer on bumpers, for example, can already cause attenuation of several dB due to resonance effects, even in the absence of repaired accident damage [26]. There are also specifications regarding the maximum attenuation of radomes to ensure that the functionality of ADAS systems is not adversely affected [27].

In the case of front-mounted cameras used to detect static and dynamic traffic objects, replacing the windscreen introduces a risk of error due to incorrect fitting of the windscreen or the camera, as well as incorrect or completely missing calibration following the repair. Furthermore, [28] suggests that a significant percentage of sensors were not correctly calibrated at the factory.

In 2023, around 2 million cases of windscreen damage to vehicles in Germany were settled through comprehensive motor insurance [29]. The actual number of windscreens replaced must be significantly higher, as not every windscreen replacement is settled through insurance. At the same time, there are indications that the front camera was not always calibrated correctly, as is actually required by the manufacturer's specifications.

An article in "kfz-Betrieb" reports on inadequate calibration [30]. It explains, by way of example, that due to a lack of standards for documenting calibrations of test equipment and test conditions, there are instances where there are significant deviations from the manufacturers' specifications. Another article in "kfz-Betrieb" highlights malfunctions in driver assistance systems caused by incorrectly or faulty calibrated sensors [31]. A study involving around 700 participating workshops found that just under 64 per cent of those with experience of ADAS had identified faults in the systems' functionality. The most common problem here was calibration not being carried out correctly.

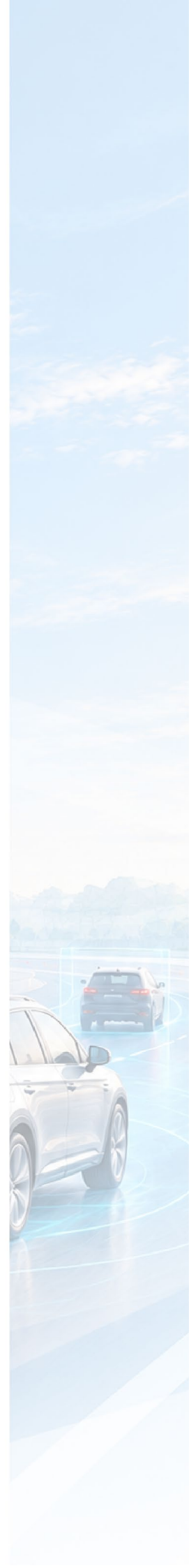




Figure 6: Incorrect setup for calibrating the front camera [30]

According to an analysis by “adasThink”, in a sample of 122 calibrations required following vehicle repairs, 88% of the calibrations were not carried out [32]. Although the representativeness of this study is limited, it shows that a lack of calibration also appears to play a significant role in the US market.

In a study, TÜV Rheinland and TRL found that, by 2029, lane departure warning systems in around 790,000 vehicles across the EU could malfunction [33]. Around 500,000 of these cases are attributable to front cameras that have not been correctly calibrated following a windscreen replacement. These figures are based on the assumption of an average potential frequency of faults and may be significantly higher in real-world conditions. Performance issues arising from other potential faults and additional ADAS systems further increase these figures.

Estimated total number of LKA related risk events in the EU in 2029

Events in mio. by scenario

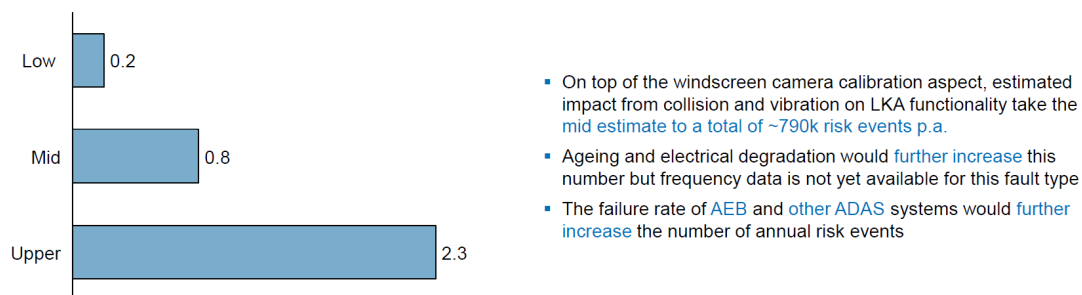


Figure 7: Potential number of vehicles with LKA malfunctions in 2029 [33]

The nature and frequency of ADAS faults in the field cannot currently be directly determined, as studies focusing on this area are either unavailable or inaccessible. However, the sources presented show that a significant number of ADAS systems in operation may exhibit faults, which often go unnoticed by the driver. Due to the limited reliability of self-diagnosis, faults in ADAS systems and their sensors can currently only be partially detected during the PTI. It is necessary to expand the PTI to include suitable test methods – for example, in the form of function and efficiency tests of ADAS – to improve the detection of ADAS-specific defects and thereby ensure the road safety of vehicles.

Extract: ADAS-related recalls

Another indicator that problems with ADAS systems can arise during operation is voluntary recalls by vehicle manufacturers or mandatory recalls ordered by market surveillance authorities (e.g. the Federal Motor Transport Authority, KBA). As ADAS systems become more widespread, ADAS-specific recalls are also on the rise. These may involve faults in the sensor systems, the software or damage caused by normal use.

In general, it is not the role of the PTI to identify systematic faults that may lead to recalls. However, if these faults result in a loss of functionality in safety-critical systems, they must be detected and reported as defects during the PTI. Furthermore, aspects such as the validity and integrity of the software (e.g. the implementation of software updates following a mandatory recall) are already checked as part of the PTI. The nature and frequency of the faults underlying recalls show that ADAS systems can exhibit faults during operation, even if they were able to demonstrate fault-free operation during type-approval.

An analysis of publicly available recalls ordered by the KBA at national level reveals a large number and wide range of recalls relating to driver assistance systems. These may, on the one hand, address ADAS systems – such as automatic emergency braking, adaptive cruise control or lane departure warning systems – as complete systems, and, on the other hand, also concern individual components, such as environmental sensors. It should also be noted that some of these faults are not detected by the vehicles' on-board diagnostics and are therefore not indicated to the driver. There are repeated recalls, in which the driver assistance systems appear to be activated in principle, but their safety-critical functions are restricted, faulty or only operational under certain specific conditions.

This is demonstrated, amongst other things, by the recalls KBA 15624R (recall date 26 September 2025) [34] and KBA 11677 (recall date 17 March 2022) [35]. In both cases, faulty software causes driver assistance systems to be deactivated without a corresponding warning being issued to the driver, meaning that the system fails to apply partial or full braking, or that the emergency braking assistant does not issue warnings. In Germany, however, only a small number of vehicles are affected by both recalls.

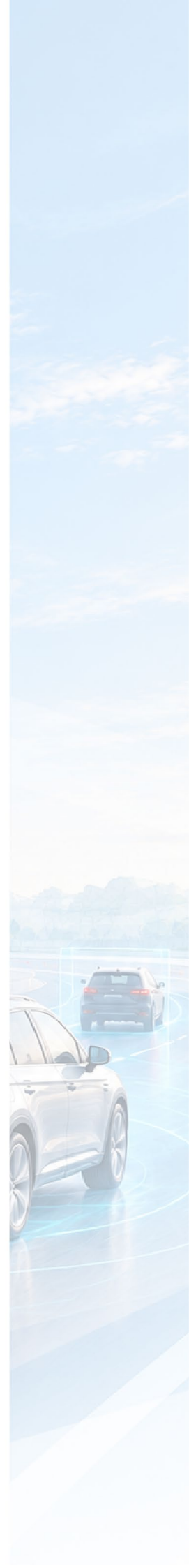
The KBA database also contains recalls that affect a more significant number of vehicles across Germany. Examples of these are recalls KBA 9818 (recall date 26 March 2020) [36] and KBA 11670 (recall date 16 March 2022) [37]. The cause of recall KBA 9818 was a software fault which could potentially lead to the automatic emergency braking assistant not functioning properly. Over 55,000 vehicles in Germany were affected by this recall. The reason for recall KBA 11670 was the possible incorrect initialisation of the radar sensor, which in turn could lead to the failure of some driver assistance systems. Over 25,000 vehicles in Germany were affected by this.

The KBA database also contains recalls of vehicles in which, for example, the warnings from an automatic emergency braking assistance system were generally correct, but automatic partial or full braking subsequently failed to occur (KBA 9124 (1 August 2019)) [38].

One example of a recall directly related to environmental sensors is KBA 15128R (recall date 21 May 2025) [39]. The recall is due to a multifunction camera and interior mirror that have been incorrectly bonded and may come loose during operation, thereby impairing various driver assistance systems.

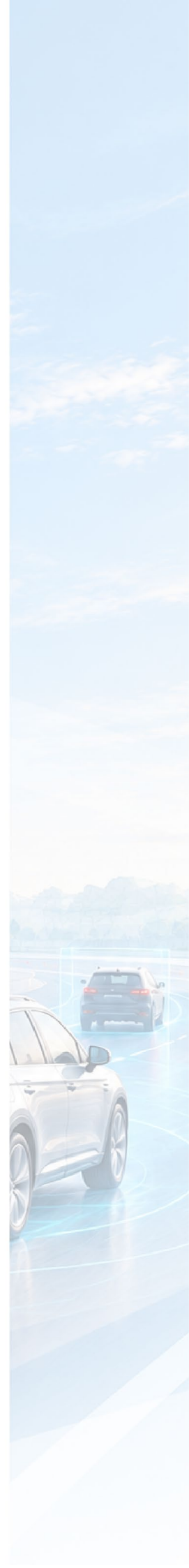
Another key area of focus is camera-based systems, particularly in relation to the UN ECE R158 type-approval regulation. For instance, there are frequent reports of camera images failing or freezing, which result in non-compliance with UN ECE R158 [40]. Examples include recalls KBA 13709 (recall date 11 June 2024) [41] and KBA 14042R (recall date 20 August 2024) [42].

Other recall databases, such as that of the ADAC, also contain a large number of manufacturer recalls directly related to ADAS and their sensors. Some of these affect a significant number of vehicles. The



reason for recall BZ4X, for example, is the potential failure of the forward collision warning system. *“A memory failure when the ignition is switched off and on again, caused by incorrect programming of the front camera systems, can lead to the front collision warning system failing. Remedy: The front detection camera is reprogrammed.”* [43] This recall affects 1,293,588 vehicles worldwide. Another recall relates to faults in AEB systems due to internal vehicle communication faults. *“An error occurs when the front camera is started. This is caused by a communication fault between the two processors in the camera that control the CMBS (Collision Mitigation Braking System). The camera may not start up correctly after the vehicle is started. The driver cannot detect this fault, as although the activation light is on, the system is not functioning. Remedy: software update.”* [44] This recall affects 172,948 vehicles worldwide.

In summary, it can be deduced from the analysis of the recalls that, whilst the vehicles’ self-diagnostic system is an essential component of ensuring the safety of driving functions, it does not detect all practical fault conditions with sufficient certainty. This applies in particular to malfunctions resulting from faulty software logic and inadequate parameterisation, but also to fault conditions specific to individual vehicles, such as sporadic memory or communication errors [45]. In particular, faults specific to individual vehicles that are not detected by the self-diagnostic system require inspection as part of the PTI. A test of function and efficiency of ADAS during the PTI is an effective way of detecting these faults and thus minimising the safety risk caused by faulty driver assistance systems.



4 Test approaches for function and efficiency tests as part of the PTI

ADAS and PTI today: fitment and condition testing

The significant potential for improving road safety through the introduction of modern driver assistance systems is only guaranteed if they function as intended by the manufacturer. This applies not only at the time of type-approval or placing on the market, but throughout the entire service life of the vehicle. The PTI is an established tool for assessing the road safety of each individual vehicle whilst in use.

In Germany and other countries (including Slovakia, Croatia, Ireland and South Korea), ADAS are already being inspected as safety-critical systems as part of the PTI, with regard to their fitment and condition. This is carried out, on the one hand, visually by inspecting the sensors for damage (e.g. stone chips in front of the camera) or by checking the warning lights on the display. In addition, the fault memory is read out via the electronic vehicle interface using the PTI-adapter, so that any anomalies detected can be assigned to standardised defects [46].



Figure 8: PTI-adapter [46]

This process also identifies ADAS-specific faults, thereby reducing associated road safety risks. In [47], an analysis of a representative sample of PTI-data reveals that, each year, more than 150,000 vehicles have defects at the time of their PTI that could directly affect ADAS. This analysis considered defects in the sensors, the ADAS systems and other relevant components. Around 5% of these defects are directly attributable to environmental sensors and ADAS.

Even today, faults detected by the vehicles' on-board diagnostics can be flagged as defects during the PTI. However, fault conditions that cannot be detected by the on-board diagnostics cannot be identified using the current inspection methods employed in the PTI. In [48] and [49], it was established that a significant number of potential faults in Intelligent Speed Assist and Lane Keeping Assist are not addressed by current fitment and condition testing. These findings are applicable to other ADAS.

ADAS and the PTI in future: addition of function and efficiency testing

The analysis of existing studies, investigations and recalls in the preceding chapters highlights the need for function and efficiency testing of ADAS as part of the PTI. Various approaches are currently being developed to expand the existing testing methods. In the Charter 2030 [50], the testing organisations in Germany have adopted the following joint position on this matter:

“In addition to static methods, scenario-based test methods offer the possibility of testing the response of the vehicle during a specific scenario by suitably depicting the traffic environment (virtually/physically). Several methods, including a dynamic vehicle inspection with a moving target or on functional test benches with environmental simulation, are being evaluated in appropriate pilot environments.” [50]

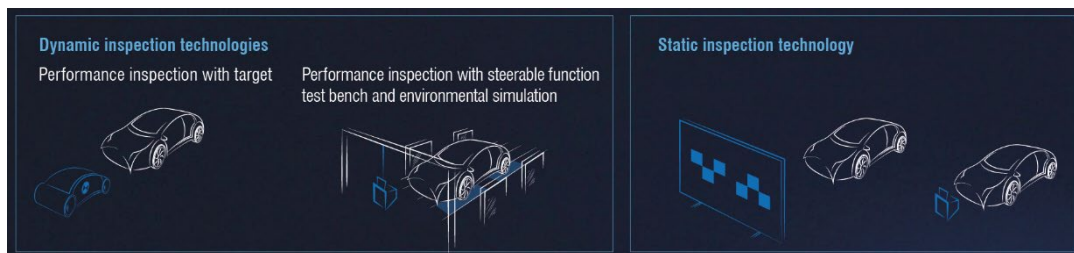


Figure 9: Approaches for function and efficiency testing of ADAS as part of the PTI [51] based on [50]

The testing of sensor systems using specific static test technology is designed to test each sensor individually. Radar target simulators can be used to test the radar sensors fitted to the vehicle; these enable the performance of each individual sensor to be assessed [52], [53]. A comparison with the performance at the time of type-approval allows conclusions to be drawn regarding the correct functioning of the sensor and the associated ADAS. This technology can also be used to virtually simulate and introduce other road users. A comparison of the simulated positions of these objects with the locations detected by the vehicle provides further information for evaluating the sensor systems. The availability and integrity of the relevant data at an electronic vehicle interface are crucial for this testing approach [54]. Calibration test benches offer a further means of verifying the current alignment of camera and radar sensors. Vehicle- and sensor-specific elements can be used to determine the alignment of the respective sensor, thereby enabling conclusions to be drawn about ADAS functionality, even though this method cannot test the entire chain of functions.

In this context, it is also worth mentioning the retrieval of the sensor calibration values currently stored in the vehicle. The analysis of this data as part of the PTI can provide indications of a malfunction in the ADAS. The use of electronic vehicle data is also essential for this approach.

Scenario-based testing approaches have been developed for testing at the overall system level. In this type of testing, the respective ADAS are tested within their Operational Design Domain (ODD) using specific scenarios. These can be carried out, on the one hand, on a roller test bench [55], [56] and, on the other hand, as part of the real-world test drive conducted during PTI [21], [57]. When using a roller test bench, static and dynamic environmental parameters must be simulated in a sensor-specific manner. If the scenario-based testing takes place as part of a real-world test drive, real-world objects are used in the form of dynamic targets and static traffic elements.

5 Findings, research needs and necessary development

Research needs

To describe the actual instances of ADAS failure in real-world road traffic in terms of their type and frequency, a study involving a meaningful number of real vehicles is required. It is therefore recommended that a study be carried out to determine the frequency of faults.

Based on this field data, the potential of the PTI to improve road safety can be more precisely identified through further investigation of the road safety potential of a function and efficiency test. Building on this, the overall societal benefit can be highlighted through a cost-benefit analysis.

Necessary development: access to vehicle data

The regular technical vehicle inspection is an established tool for ensuring road safety in operation. To be able to verify the proper functioning of driver assistance systems during the PTI, the testability of the systems must be taken into account as early as the development stage and in the type-approval regulations. The regulator has already recognised this to some extent. For instance, Delegated Regulation (EU) 2021/1958 on the type-approval of intelligent speed assistance systems stipulates [58]:

For the purposes of periodic technical inspections, it must be possible to verify the following characteristics of the ISA:

[...] the correct functioning and software integrity through the use of an electronic vehicle interface [...] Manufacturers must ensure that the technical information required for the use of the electronic vehicle interface is made available in accordance with Article 6 of Regulation (EU) 2019/621 (3).

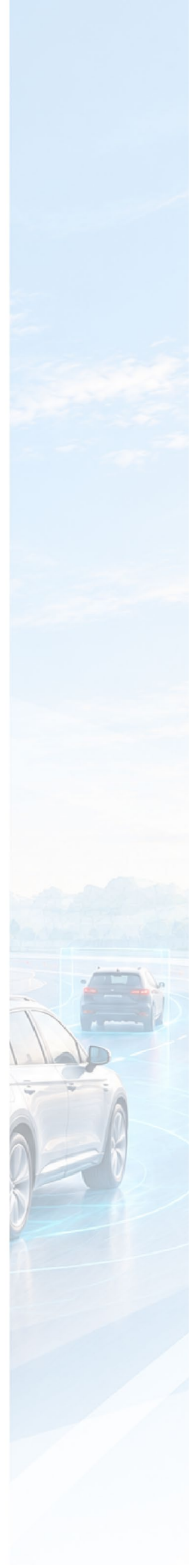
In order to be able to apply effective and efficient test methods for the function and efficiency testing of ADAS and their environmental sensors for all driver assistance systems and automated driving functions as part of the regulatory activities of the PTI, standardised data from the relevant assistance systems and their components via the electronic vehicle interface, as well as data on the vehicle or vehicle model to be tested, will be mandatory in future.

The requirement for ADAS-test-relevant data, which must be available at the vehicle's electronic interface during the PTI, can be summarised into four categories:

- Live and operational values
- Identity, integrity and version characteristics
- Calibration data
- Diagnostic Trouble Codes (DTC)

Further data describing the vehicle model or specific equipment variants must be known to correctly assess the vehicle and its systems. These include, amongst others:

- Vehicle geometry data
- Sensor- and control unit-specific information
- Description of ADAS functional parameters



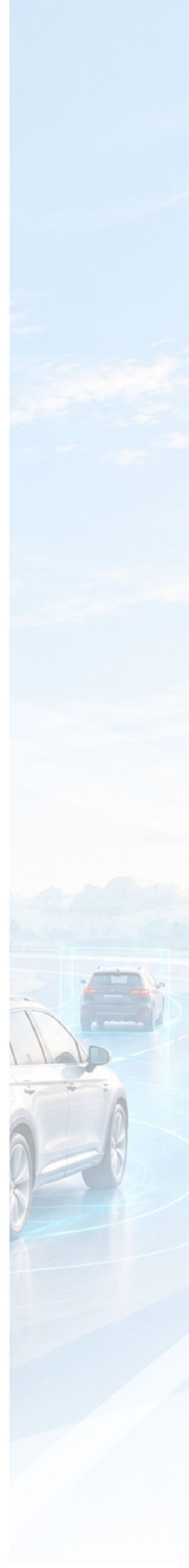
Findings

The mandatory use of ADAS significantly improves road safety. As these safety-critical systems become increasingly widespread, the number of people killed and injured in road traffic accidents will continue to fall in the coming years. However, it is also evident that, as currently specified, ADAS do not have an impact on all road traffic accidents. An increase in the minimum requirements for these systems is necessary.

The potential for improving road safety depends on the specific system and is reduced in real-world operation by instances of failure. Damage, improper repairs, faulty or completely missing calibrations, or deliberate modifications to the vehicle can reduce this potential to a significant extent. Of particular concern are functional impairments that are not detected or are tolerated by the system's self-diagnostic functions, and thus remain unknown to the driver until the system is expected to intervene.

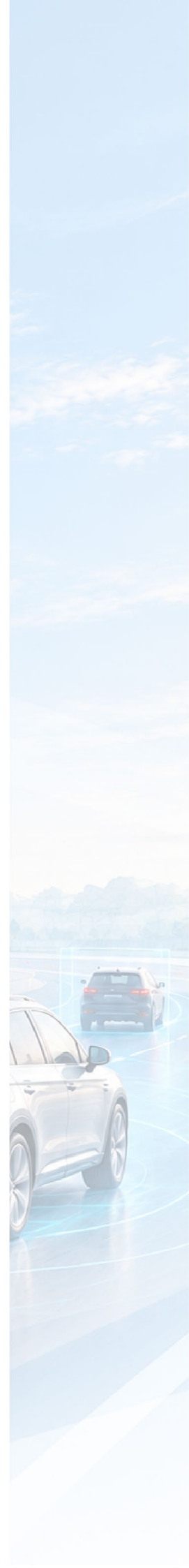
Even today, some of the potential faults can be identified as part of the PTI. However, a significant number of defects cannot be detected using the testing methods currently in use. These faults can be identified by carrying out function and efficiency tests on the systems. An extension of the PTI is therefore necessary in order to significantly improve the depth of testing and thus further enhance road safety.

It is not possible to quantify precisely the number of faults in the field that currently go undetected, given the data currently available. However, an analysis of a wide range of sources shows that functional impairments in safety-critical ADAS systems represent a significant problem.

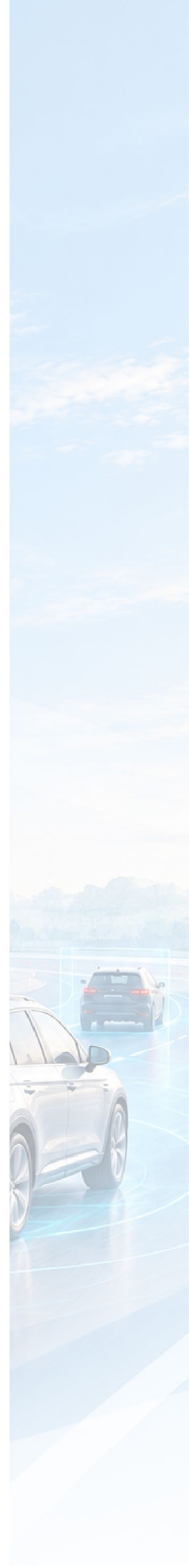


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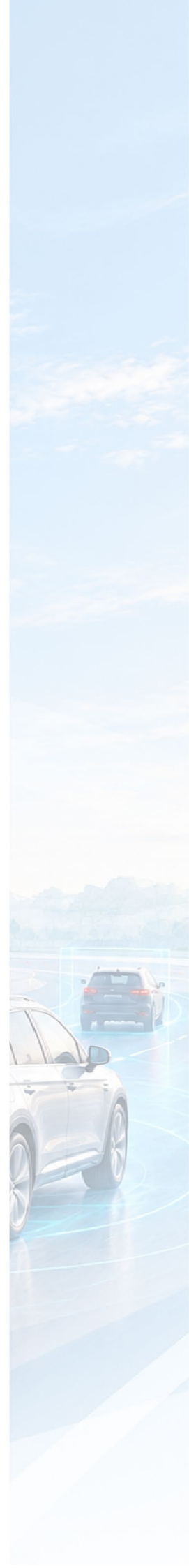


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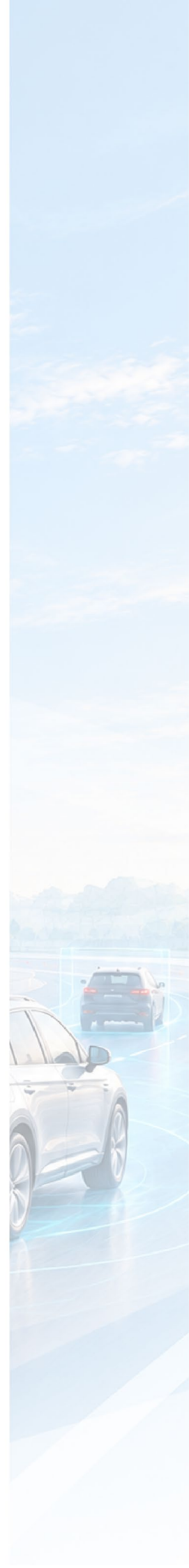


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