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Road Safety Thematic Report

Advanced driver assistance systems

This document is part of a series of 20 thematic reports on road safety. The purpose is to give road safety practitioners an overview of the most important research questions and results on the topic in question. The level of detail is intermediate, with more detailed papers or reports suggested for further reading. Each report has a 1-page summary.

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Contents

Summary

ADAS in road traffic

Advanced Driver Assistance Systems (ADAS) are available in almost all new car models on the market. The level of automation of these systems ranges from warning and momentary assistance systems (SAE level 0), continuous lateral or longitudinal driver support (SAE level 1), to partial automation (SAE level 2). This report briefly describes the operation, safety benefits and challenges of ADAS.

Safety Benefits and Challenges

Generally, ADAS for collision avoidance show the greatest safety benefits. These systems support the driver only in hazardous situations, showing that here the added automation perception and quicker automation reaction times can indeed be beneficial for road safety. Also, Intelligent Speed Adaptation, especially when it is restrictive, is expected to significantly improve safety. With higher levels of automation the safety benefits are less clear. The safety estimates shown in Table 1 are based on the literature referred to in this report and the overviews found in (Vlakveld, 2019), (Hynd et al., 2015) and (Seidl et al., 2017).

ADAS SAE level 0	Safety Benefits
Forward Collision Warning (FCW)	+/-
Automatic Emergency Breaking (AEB)	+
FCW + AEB	++
Assisted Emergency Steering (AES)	Unknown
Parking Sensors, Rear Vision Camera & Automatic Braking	+/-
Rear Cross Traffic Assist (RCTA)	+
Front Cross Traffic Assist (FCTA)	Unknown
Left and Right Turn Assist (L/RTA)	Unknown
Intelligent Speed Adaptation (ISA):	
Warn	+/-
Assist	+
Restrict	++
Curve Speed Warning (CSW)	Unknown
Lane Departure Warning (LDW)	+/-
Lane Keeping Assist (LKA)	+
Blind Spot Monitoring (BSM)	+/-

ADAS SAE level 1/2	Safety Benefits
Adaptive Cruise Control (ACC)	Conflicting results
Lane Centering (LC)	No clear benefit
ACC + LC	No clear benefit

Table 1: Overview of ADAS safety benefits. -/+, + and ++ indicate slight, reasonable and great safety benefits.

ADAS also faces challenges such as driver-ADAS interaction. These challenges concern system transparency, trust, mode confusion, and keeping the driver attentive while monitoring the ADAS. Other challenges relate to interaction with other road users, mainly concerning the predictability of driving behaviour. Finally, ADAS is also faced with technological challenges such as detection accuracy, sensor ranges, and detection of vulnerable road users.

1 Highlights

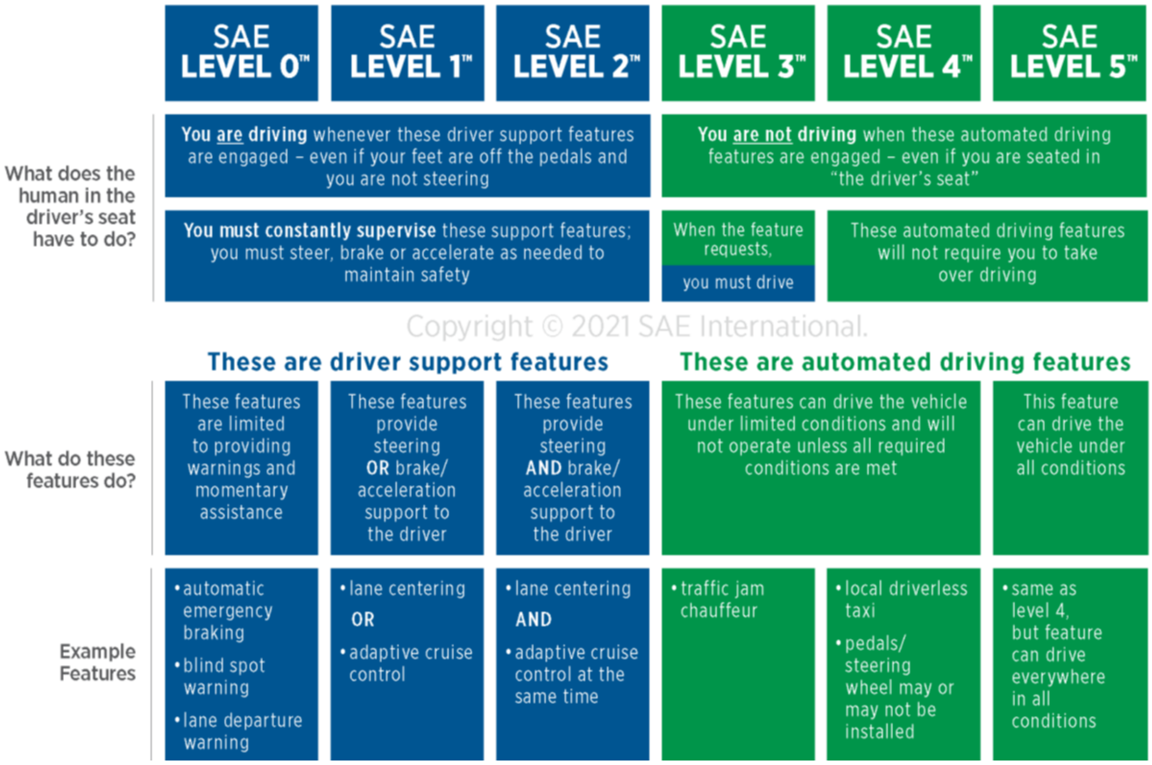
- *ADAS can improve road safety.*
- *ADAS with SAE Level 0 currently show the highest safety potential.*
- *Several ADAS with SAE level 0 will be mandatory in the EU by 2022.*
- *No automated driving technology is allowed yet on the EU market.*
- *Safety benefits can only be fully realized when human factor challenges are addressed.*

2 What is ADAS?

2.1 Focus

Nowadays all new car models are equipped with some form of Advanced Driver Assistance Systems (ADAS). While there is no single definition of ADAS, generally they refer to systems that support the driver in their primary driving task. The term "advanced" refers to the use of sensors to observe the surroundings. These systems can inform or warn the driver, but also take over (part of) vehicle control.

The Society of Automotive Engineers (SAE) has proposed 6 levels of driving automation (Figure 1). ADAS fall under levels 0-2, while automated driving (AD) refers to levels 3-5. The main difference between ADAS and AD is the role of the driver. While ADAS only support the driver with their driving task, AD can take over the complete driving task for at least part of the trip. Currently, no AD systems have gained EU approval. Some ADAS, on the other hand, have gained approval and will be mandatory in future car models.



	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 features 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 features can drive the vehicle under limited conditions and will not 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: SAE J3016 levels of driving automation from SAE International.

This report only covers ADAS that use sensors to monitor the *surroundings* of the vehicle, following the definition given by the Dutch Safety Board (2019). Systems that only use sensors that measure *vehicle* states (e.g., tire pressure monitoring and electronic stability control) or *driver* states (Driver Monitoring Systems) are not included. Systems that only enhance perception, but do not warn the driver or take over control of the vehicle (e.g., adaptive headlights, night vision and back up camera) or that are not focussed on improving safety (e.g., automatic parking) are also excluded. This results in the set of ADAS as shown in Figure 2. In this figure, the features which will be mandatory for new car models in the EU from 2022 are indicated with a red asterisk. More information on this can be found on the EC website. Section 6 additionally presents a brief outlook to Automated Driving (AD) systems.

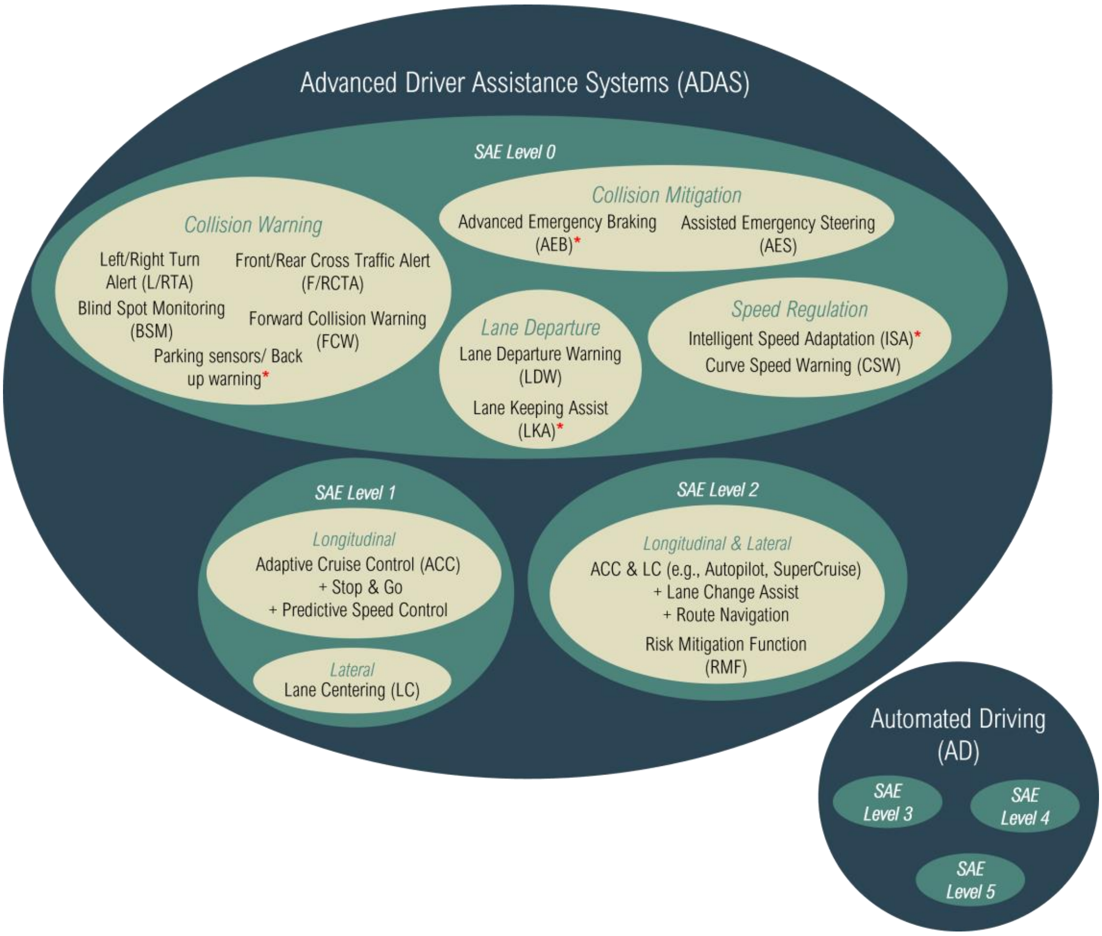


Figure 2: ADAS covered in this report

To understand differences within ADAS it is helpful to look at the sensors and sensor ranges that condition their features (see Figure 3). For example, at low speeds short-range parking sensors can be used to detect obstacles all around the front and back of the vehicle. In contrast, at higher speeds, the longer range of adaptive cruise control can be used to detect vehicles further in front of the car, but within a smaller lateral range. Sensor ranges therefore explain some of the limitations of different ADAS. Generally speaking, the longer the longitudinal range of a sensor the narrower is its capacity. Also long-range sensors are used at higher speeds than short-range sensors.

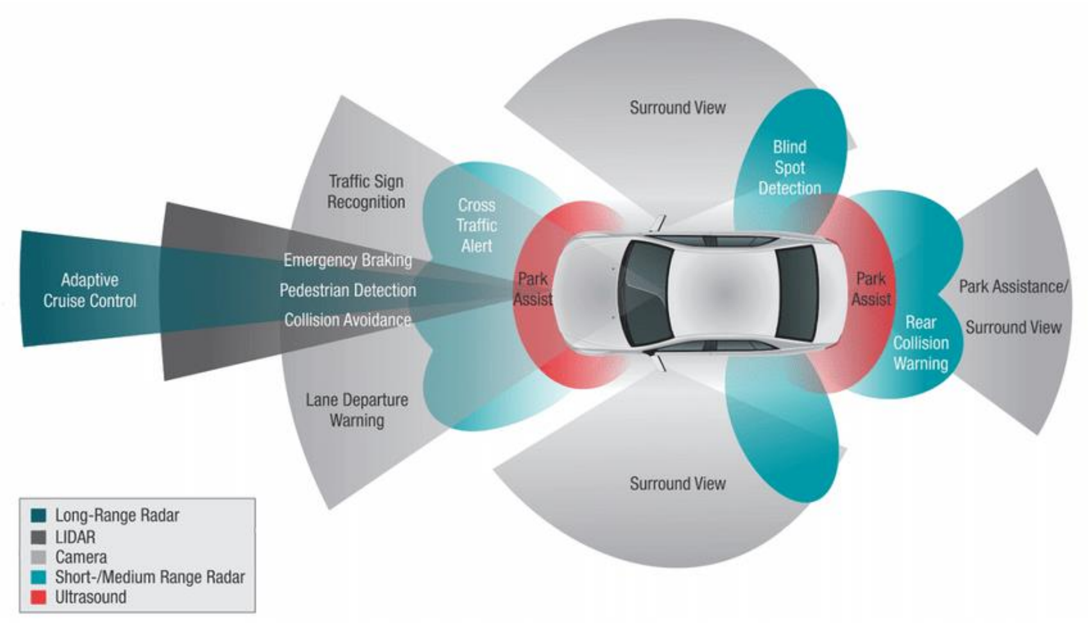


Figure 3: Typical ADAS sensor ranges (Texas Instruments).

2.2 General safety benefits and challenges of ADAS

Generally, the safety benefits of ADAS are improved reaction time, improved perception, and not being susceptible to typical human factors such as drowsiness and distraction. For example, some ADAS use cameras mounted on the back of the vehicle to inform the driver of hazards behind the vehicle which otherwise would be out of sight. As soon as a hazardous situation is detected, the ADAS can almost instantly brake or steer to mitigate collisions. While these capabilities result in measurable safety benefits of some ADAS (which are discussed in the following sections), there are also still challenges that need to be addressed: typical challenges are:

- Human-vehicle interaction (Carsten & Martens, 2019)
  - A lack of *system transparency*, i.e. insufficient understanding of how the system works, and its capabilities and limitations can cause surprises for the driver. This in turn can result in, for example, longer reaction times in critical situations.
  - Inappropriate *trust* in the system can either lead to disuse of the system (distrust) or misuse of the system (overtrust). The system might then be deactivated while it could have improved safety, or be activated in situations it is not designed for.
  - *Mode confusion*, where the driver is confused about whether a certain feature is activated and/or can perform a particular task.
  - *Keeping the driver in the loop* is especially challenging in higher levels of automation, where driver workload is significantly reduced. Drivers might become distracted or fatigued and not be able to adequately perform their monitoring task.
- Interaction with other road users (Brown & Laurier, 2017; Cicchino, 2019a; Knoop et al., 2019; van den Beukel et al., 2021)

    - Human drivers in part compensate for their long reaction times by anticipating hazardous situations. When automation behaves in a significantly different way to human drivers, this ability to *anticipate* is impaired.
    - Many driving situations require some form of *communication* between road users. As ADAS is generally not designed for such communication, this can cause confusion.
- Technological limitations
    - The *accuracy* of ADAS is still dependent on the specific circumstances, such as quality of lane markings or weather conditions.
    - *Sensor ranges* are still limited and *perception* of vulnerable road users is often poor.

Many of these challenges can be addressed by taking a *human-centred design approach* in the development of ADAS. In this respect, both the ADAS and the human-machine interfaces are designed with human capabilities and limitations in mind. *Driver monitoring systems* can aid in keeping the driver in the loop, by monitoring driver state and taking measures to avoid distraction and fatigue. These systems will become mandatory in all new car models in the EU in 2022. Also, *informing drivers* of the capabilities and limitations of ADAS can also aid system transparency and generate appropriate trust.

Research into challenges regarding ADAS and other road user interaction has only lately been gaining traction. These challenges can be addressed through further research into road user interaction and using the findings in the development of future ADAS.

Much research is already being undertaken on the technological side. For example, the perception of vulnerable road users is being improved. Car manufacturers also continue to extend the range of circumstances under which certain ADAS can operate.

3 How do Level 0 ADAS perform in traffic?

3.1 ADAS at Level 0

SAE level 0 ADAS can provide warnings and momentary assistance. For example, collision avoidance systems only assist the driver when a collision is imminent by means of warnings, or braking or steering interventions.

There are several *collision warning* systems that each have a different field of view and range and therefore detect objects at different positions around the vehicle. **Forward Collision Warning (FCW)** warns the driver of obstacles centrally in front of the vehicle at relative far distances. This long range makes it possible to detect and react to obstacles in front while driving at relatively high speed, such as highway driving. **Cross Traffic Alert (CTA)**, on the other hand, detects vehicles closer to the vehicle and at a wider lateral range than FCW (see Figure 3). Due to this shorter longitudinal range, CTA operates at low speeds, such as when backing out of a parking spot or approaching crossings with an obstructed view. Its wider range makes it possible to detect traffic that is on a crossing path with the vehicle. **Park assist sensors** often have an even shorter range and are therefore only effective in avoiding collisions with stationary objects.

Some collision avoidance systems are linked to a turn signal being switched on. These systems assist the driver in assessing their surroundings before they start turning. Examples of such systems are the **Blind Spot Monitoring (BSM)** system and the **Left and Right Turn Alert (L/RTA)** functions. BSM warns the driver whenever there is a vehicle in their left or right blind spot and provides an additional audible warning if in such situation the turn signal is switched on. Warnings will appear in the sideview mirrors or in the windshield frame. LTA often only focusses on oncoming traffic, while the RTA detects road users at the side of the vehicle. ADAS, like BSM and FCW, originally focussed on other vehicle detection while the newer RTA, BSM and FCW functions can also incorporate **pedestrian and cyclist detection**.

Collision mitigation systems can activate the brake pedals or steering wheel to avoid a collision. **Advanced Emergency Braking (AEB)** can detect obstacles in front of the vehicle and will also brake until a full stop to avoid or reduce the impact of a collision. **Advanced Emergency Steering (AES)** detects obstacles in front of the vehicle and will initiate an evasive steering action if braking would not avoid a collision. To determine the optimal steering path, it also uses sensors that look around the vehicle. Collision mitigation systems can be combined with warning systems, so that the driver is warned about an imminent collision before the ADAS actuates any controls.

In addition to the collision avoidance related ADAS, there are also SAE level 0 ADAS related to *speed regulation*. **Curve Speed Warning (CSW)** systems, for example, warn the driver about unsafe speeds during curves. The more elaborate **Intelligent Speed Adaptation (ISA)** function compares current driving speed to one of three types of speed limit (Carsten & Tate, 2005): 1) fixed speed limits, i.e. posted speed limit at a location; 2) dynamic speed limits, which additionally take account of the actual road and traffic conditions (weather, traffic density); and 3) variable speed limits, which additionally take account of special locations such as road construction sites, pedestrian crossings and sharp curves. In case of speeding, the ISA system can *warn* the driver (e.g. with audio visual signals), *assist* the driver (e.g. with a haptic throttle, which provides resistance above the speed limit), or even *restrict* the driver from going faster (e.g. the dead throttle, which makes it impossible to go faster than the local speed limit) (van der Pas et al., 2012). ISA can further be categorized by whether it can be switched off by the driver (*overridable* vs. *non-overridable*). The EU will make the overridable ISA with acoustic warnings or with assistance mandatory by 2022 for all new car models.

Finally, there are also SAE level 0 ADAS related to *lane departure* which help the driver stay within lane boundaries. **Lane Departure Warning (LDW)** systems provide a warning when the vehicle is about to veer out of lane. **Lane Keeping Assist (LKA)** also actively steers to keep the vehicle within lane boundaries.

3.2 Safety benefits

The safety benefits of ADAS depend on the prevalence and severity of the crashes they aim to prevent, their effectiveness in preventing them, and the side effects they might generate. The safety effectiveness of ADAS is often shown by comparing the prevalence of specific crash types between vehicles with and without the system in place, using police-reported and insurance crash data. Such studies show that **Forward Collision**

Warning (FCW) systems can reduce rear-end striking crashes with injuries by about 20% (Cicchino, 2017; IIHS, 2020; Leslie et al., 2019). These studies also show that **Advanced Emergency Braking (AEB)** systems can reduce such crashes by about 45% and the combination of FCW and EAB can reduce these crashes by about 55%. Some vehicles are also equipped with **Advanced Emergency Steering (AES)** systems, such that the vehicle can perform an evasive manoeuvre when the braking distance is too short to avoid a crash. Several simulation studies (Dang et al., 2012; Kovaceva et al., 2020) show the potential benefit of such systems in reducing pedestrian and cyclist forward collisions.

Backing crashes are generally at low speed and less severe, limiting the safety potential of systems that aim to avoid them. However, the effectiveness of ADAS in avoiding backing crashes is relatively high. A police-reported crash data study (Cicchino, 2019a) showed that vehicles with **parking sensors** combined with a rear vision camera showed a reduction of 42% in police-reported backing crashes. When combined with rear automatic braking, a 78% reduction was even found. **Rear Cross Traffic Alert (RCTA)** can complement these backing assistant systems by detecting cross traffic as well. They can reduce backing crashes involving two perpendicular vehicles by even 32% (Cicchino, 2019b).

In Europe about 38% of car-to-car crashes happen at intersections (Wisch et al., 2019). Some car manufacturers have therefore designed intersection assist features such as **Front Cross Traffic Alert (FCTA)** and **Left and Right Turn Alert (LCTA)**. As these systems do not have high market penetration, real world effectiveness studies are not yet available. However, in (Sander et al., 2019) the effectiveness of such a system combined with AEB, generally named Cross Turn *Assist*, is simulated using detailed crash data from in-depth studies in Germany and this was found to potentially be effective against intersection-related collisions.

Excessive speed is a causal factor in about one third of fatal road accidents (Ryan, 2018). It is estimated that **Intelligent Speed Adaptation (ISA)** can contribute to reducing these road accidents. While the estimates in literature differ (Ryan, 2018), it is generally assumed that the more controlling the system is (i.e. warn, assist or restrict), the higher its contribution to road safety. Assisting ISA, which will be mandatory in the EU by 2022, is estimated to reduce fatal road accidents by 3-32% and serious accidents by 1-25%. A special case of open, dynamic ISA are **Curve Speed Warning** systems, which are designed to aid curve negotiation through sharp curves: however, no real world effectiveness studies on reducing crash risk with such systems were found.

Lane Departure Warning (LDW) systems can alert the driver when the vehicle is unintentionally drifting outside lane boundaries. Studies comparing police-reported crashes between vehicles with and without LDW (Cicchino, 2018; Leslie et al., 2019) estimated that these systems reduced injury crashes for which they are designed (e.g. lane departure crashes) by 10-21% (Cicchino, 2018; Leslie et al., 2019). **Lane Keeping Assist (LKA)**, which not only warns the driver, but also gently steers the vehicle back into the correct lane, is estimated to reduce injury crashes related to lane departure by 20%-30% (Leslie et al., 2019; Sternlund et al., 2017). **Blind Spot Monitoring (BSM)** systems are estimated to reduce crashes related to lane-change by 14% and lane change crashes with injuries by even 23% (Cicchino, 2018a; Spicer et al., 2018).

3.3 Challenges

As described in Section 2.2, ADAS have to cope with several challenges related to human factors. If the driver does not fully understand the capabilities and limitations of the system, this might lead to mode confusion and can cause surprises for the driver. For example, a rear cross traffic assist feature has a much smaller field of view when backing out of an angled parking space and therefore will not detect all cross traffic (e.g., Volvo Cars website). If this is not known to the driver, he/she can be surprised when cross traffic is not detected. On the other hand, when the ADAS incorrectly detects obstacles or lane boundaries, this can lead to phantom braking or steering (Moscoso et al., 2021).

Drivers might also develop too much trust in the ADAS and become less vigilant (Maltz & Shinar, 2007; Miller & Boyle, 2019). Other negative behavioral adaptations can, for example, be an increase in driving speed or closer car following (Sullivan et al., 2016; van der Pas et al., 2012).

ADAS can also have an adverse effect on other road users. Autonomous Emergency Braking (AEB) systems, for example, can cause vehicles to be struck in rear-end crashes when the vehicle behind the AEB-equipped vehicle cannot brake in time to avoid a crash. Police-reported crash data showed that the incidence of vehicles with both FCW and AEB being struck from behind is 20% higher than with vehicles without these systems, and 4% higher in cases of collisions with injuries (Cicchino, 2017). It is likely, however, that such accidents will occur less frequently when more cars are equipped with AEB.

4 How do Level 1 ADAS perform in traffic?

4.1 ADAS at Level 1

SAE level 1 ADAS can provide continuous steering or brake/acceleration support in specific circumstances. These ADAS are generally called **Adaptive Cruise Control (ACC)** for longitudinal control and **Lane Centring (LC)** for lateral control.

ACC automatically adjusts the vehicle speed to maintain a safe following distance and stay within the set speed. When braking is needed, the ACC can usually achieve up to 30% of the vehicle's maximum deceleration. When greater deceleration is needed, the driver is warned by an auditory signal. Conventional ACC can generally be activated at a speed of about 30 km/h or higher. Some ACC have a **stop & go** function, which allows the ACC to bring the vehicle to a full stop so that the ACC can also be used in traffic jams. A new ACC functionality is **Predictive Speed Control**, which links the ACC with the navigation system and other sensors so it can adjust speed to current speed limits and slow down before bends, crossroads, and roundabouts. ACC with this functionality are also called predictive ACC.

The **LC** feature automatically steers the vehicle to keep it at the centre of the lane. This differs from Lane Keeping Assist, which only provides moderate steering input when the vehicle is already drifting and lane boundaries are about to be crossed. At lower speeds the LC feature often uses the vehicle in front to stay in the centre of the lane, and at higher speeds lane boundaries are used. These systems generally provide only moderate steering input and always require the driver to keep their hands on the steering wheel. Very often the LC feature can only be switched on when ACC is activated; this combination then becomes a SAE level 2 system.

4.2 Safety benefits

Adaptive Cruise Control (ACC) was developed as a comfort and convenience system rather than a safety system. It therefore does not perform evasive manoeuvres such as those performed by Advanced Emergency Braking (AEB). Some overview reports hypothesize potential positive safety effects of ACC resulting from, for example, reduced average speed and reduced frequency of very short time headway (Hynd et al., 2015; SWOV, 2010). However, these reports also mention the potential negative effects of ACC such as increased distraction due to low workload and delayed reaction times. Generally it can be concluded that ACC does not have a clear positive effect on road safety.

In a study from the Highway Loss Data Institute (HLDI, 2019), insurance claim frequencies of BMW vehicles from model years 2013-2017 with specific collision avoidance packages were compared to models without any of the selected packages. The analysis indicated that ACC possibly reduces the frequency of crashes with injuries, as the claim frequency of such crashes seemed to reduce between packages without and with ACC. However, no significance testing was applied for that specific comparison. In the same study, a reduction in crash frequency was *not* apparent for **Lane Centering (LC)**. No other studies on the real world safety benefits of LC were found.

4.3 Challenges

Both ACC and LC take over large parts of the driving task and this can lead to driver underload. This in turn can lead to distraction and longer reaction times to unforeseen situations requiring sudden intervention by the driver. Also, when a driver does not realize that a particular feature is deactivated (mode confusion), this can lead to longer reaction times as the driver assumes the automation will brake or steer. This mode confusion is a risk especially with systems that provide visual feedback only and no auditory warning when the system is deactivated (Carsten & Martens, 2019).

The reliability of both systems is highest during highway driving, but they do not perform well on curved roads. For example, ACC might accelerate during curves when it detects a vehicle further ahead in the adjacent lane in its narrow line of sight (e.g. Volvo Cars website). LC might only provide moderate steering input, which is not enough to drive through sharper curves (e.g. Daimler website). If drivers are unaware of such system limitations and/or do not fully comprehend the consequences of improper use of these systems, this might cause automation surprises and negatively impact on road safety.

These challenges can be addressed by ensuring that users understand how the features on their car work, what their limitations are, and what the driver's responsibility entails. This understanding can be accomplished by designing ADAS and their interfaces using a human-centered design approach.

5 How do Level 2 ADAS perform in traffic?

5.1 ADAS at Level 2

SAE level 2 ADAS can combine lateral and longitudinal control of the vehicle under specific circumstances. Generally this means a **combination of Adaptive Cruise Control (ACC) and Lane Centring (LC)**. Well-known examples of level 2 systems are Tesla's "Autopilot" and Cadillac's "Supercruise". However, most car manufacturers now offer level 2 systems under varying names and with varying added functionalities.

Car manufacturers often offer stop & go ACC with LC and Blind Spot Monitoring as one system package. Some car manufacturers choose to also add other SAE level 0 type ADAS to the same package. An example of a feature that is generally only offered in combination with a level 2 type system is **Lane Change Assist**, which can automatically perform a lane change manoeuvre after the driver has initiated or approved the lane change. Newer level 2 systems also sometimes offer **Route Navigation**, where the vehicle can perform highway driving from entrance ramp to exit ramp by following the navigation route. While these systems appear to take over the driving task completely, the driver is still obliged to monitor the driving situation and, in the EU (Pipkorn et al., 2021), keep their hands on the steering wheel.

Specifically for emergency situations where the driver is unresponsive, a system called **Risk Mitigation Function (RMF)** is currently under development. This function can, in case of confirmed driver unavailability, automatically activate the vehicle steering system for a limited duration to steer the vehicle with the purpose of bringing the vehicle to a safe stop within a target stop area, such as the road shoulder. As this function is not yet available on the market, no further information on safety benefits or challenges can be provided here.

5.2 Safety benefits

Some manufacturers claim safety benefits of their SAE level 2 ADAS. The comparisons which form the basis for these claims may not however be convincing. For example, a comparison of the crash rates when the level 2 ADAS is activated and when not includes more differences than just the ADAS activation. Generally, level 2 ADAS are activated on highways in easy traffic where collisions are less likely to occur. A paper currently under review (Goodall, 2021) shows that the apparent safety benefits of Tesla's SAE level 2 ADAS "Autopilot" compared to their Active Safety Only features can be largely explained by such road type differences.

A study comparing insurance claims between BMW models with different ADAS packages (HLDI, 2019) also shows no clear safety benefit of their SAE level 2 package "Driver Assistance Plus" as compared to their SAE level 1 package "Driver Assistance". No other studies on the real world safety benefits of SAE level 2 ADAS were found.

5.3 Challenges

Driving with SAE level 2 ADAS relieves the driver of most steering, braking and accelerating tasks, but the driver still needs to monitor both the traffic environment and the system. In (Carsten & Martens, 2019) an overview is given on challenges related to such systems: for example, driver underload can cause boredom, distraction and drowsiness which prevents drivers from properly performing their monitoring task.

To avoid such behaviour, **Driver Monitoring Systems** (DMS) can be installed. Most vehicles with SAE level 2 ADAS have some form of DMS. Monitoring driver drowsiness and driver distraction will be mandatory in the EU for all new vehicle models by 2022 and 2024 respectively. Not all forms of driver monitoring, however, are equally effective. For example, drivers have been observed to mislead monitoring systems based on hands-on-wheel detection by placing weights on the steering wheel. Driver monitoring based on eye tracking might be more effective against misuse.

In order to avoid overtrust, another solution would be to properly inform the driver and create a transparent ADAS so that system limitations are apparent to the driver. Properly informing the driver should start with the ADAS nomenclature. Much controversy has been generated by the name "Autopilot", for example, which suggests that the vehicle can drive by itself. It has been shown that such names are correlated with overestimation of the system capabilities (Teoh, 2020). Recent research also suggests that the framing of messages about ADAS may influence the perceived reduction of safety risks (Dixon, 2020; Harms et al., 2021; Singer & Jenness, 2020).

6 Outlook to Automated Driving

While not yet available on the European market, many car manufacturers are also working on higher levels of automation, called Automated Driving (AD). In fact, Mercedes-Benz has just gained approval under UN Regulation No 157 (see UNECE website or link to the Regulation) for their level 3 system called Automated Lane Keeping System, and if national legislation allows, will bring it to market in 2022. These systems can take over the driving task completely, at least for some period of time. For SAE level 3 and 4 systems, it is still possible for the driver to be asked to retake control. One of the major risks with these systems is exactly this takeover of control. When drivers have been out of the driving loop for a while, they need time to regain situation awareness and physically take back control of the vehicle. Much research is being undertaken on how to best facilitate this. When lower levels of AD reach the European market, well-functioning driver monitoring and an appropriate human-machine interface will be crucial for realising their potential safety benefits.

7 Further reading

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