Intelligent transport and advanced driver assistance systems (ITS and ADAS)

SWOV Fact sheet, April 2019

Summary

Intelligent transport and advanced driver assistance systems are implementations of information and communication technology in vehicles and in the transport infrastructure to make traffic safer, more efficient, more comfortable, more reliable and more eco-friendly.

ITS is short for Intelligent Transport Systems. A significant number of in-vehicle ITS are so-called Advanced Driver Assistance Systems (ADAS). Part of these driver assistance systems are intended to support drivers in their driving tasks. Examples are systems that warn drivers or intervene when they unintentionally steer out of their lanes, do not maintain enough headway to the vehicle in front, or drive or corner too fast. Other systems are intended to enhance driver comfort - navigation systems for instance - while also affecting road safety.

This fact sheet is restricted to in-vehicle intelligent systems that (possibly) affect road safety.

Generally speaking, driver assistance systems have made cars safer, but their effects vary considerably. Systems that intervene are usually more effective than systems that are restricted to warning the driver. When assessing the effects, the possibility of a change in drivers' behaviour (behavioural adaptation) because of the presence of a driver assistance system should be taken into account. This implies that the hypothetical effect may, in actual fact, turn out differently. Moreover, drivers often do not know which systems have been implemented in their cars, which means these systems are by no means always (fully) taken advantage of.

In-vehicle ITS/ADAS should be implemented in such a way that these systems do not become a source of distraction or confusion themselves. This calls for an appropriate and uniform design, preferably attuned to the perceptive and cognitive abilities of older drivers. At this time, there are no legal requirements ITS/ADAS have to comply with, although (European) recommendations and general design principles have been established.

1 What is meant by intelligent transport and advanced driver assistance systems (ITS and ADAS)?

The umbrella term 'Intelligent Transport Systems' (ITS) refers to the use of information and communication technology in vehicles and/or the infrastructure to make traffic safer, more efficient, more comfortable, more reliable and more eco-friendly.

This fact sheet is restricted to in-vehicle intelligent transport systems that (possibly) affect road safety. This concerns stand-alone devices ('nomadic devices') such as a smartphones or navigation systems, but particularly integrated devices. The latter are to be found in cars, delivery vans, lorries and buses and – to a lesser extent – in (powered) two-wheelers. A large share of in-vehicle ITS consists of the so-called Advanced Driver Assistance Systems (ADAS). These are to be defined as systems that contribute to road safety by preventing collisions, or by mitigating the severity of collisions and by assisting in the post-crash phase [1]. They support the driver by preventing unintentional lane departure, by maintaining appropriate headway or speed, by braking in case the driver does not do so swiftly enough or warning in the case of driver fatigue. The way in which this is done may vary between systems and manufacturers.

Different names for systems offering the same kind of support abound. There are numerous abbreviations for advanced driver assistance systems according to brand or implementation. This is hard for consumers and also affects the use of these systems [2] [3]. It also makes it difficult to determine the number of vehicles equipped with these systems (penetration rate) and what their road safety effect is. On the American website https://mycardoeswhat.org, the 30 most prevalent systems are each explained in a video.

2 Have ITS and ADAS made cars safer?

Generally speaking, ITS and ADAS have made cars safer, but the effect of the various systems differs greatly. Some systems do not help at all or only slightly, while the effect of other systems is unknown, and only a few have a significant (positive) effect on road safety. ITS and ADAS with a significant negative effect on road safety have not been observed yet, although some systems may lead to distraction or reduced alertness (also see the question *What are possible disadvantages of ITS and ADAS?*). Systems are mainly intended to increase comfort and to control traffic flows, and significant effects on road safety should therefore not be expected. Nevertheless, these expectations do exist, as is the case with Adaptive Cruise Control and navigation systems.

By and large, autonomously intervening systems are more effective than advisory or warning systems. This was shown in studies of the effectiveness of an advisory versus an intervening form of intelligent speed assistance ([4], also see the question *What is Intelligent Speed Adaptation (ISA) and what effects does it have on road safety?*). An example of an autonomously intervening system is Electronic Stability Control (ESC). For each car wheel, the system measures whether the vehicle is going in the direction the driver is steering to. In case of deviation, the car may start skidding. By applying the brakes to individual wheels, this is prevented. Of course, this may not always work; speeds may be too high or road surfaces too slippery. Research has shown that ESC has a profound effect on single-vehicle crashes and a significant effect on multiple-vehicle crashes (amongst other [5]). A conservative estimate for the Netherlands is that ESC would result in a 30% reduction in single-vehicle crashes and a 17% reduction in fatal multiple-vehicle crashes [6]. Since 2014, ESC has been mandatory for new cars in Europe.

Sometimes, however, a combination of systems is most effective. American research by insurance companies [7] shows that a combination of Forward Collision Warning (FCW; warns drivers when they do not maintain enough headway to the vehicle in front) and Autonomous Emergency Brake (AEB; automatic braking when the driver fails to respond to the FCW signal swiftly enough) results in a 40% reduction of injury crashes in the case of rear-end collisions, whereas solitary FCW did not have an effect on (rear-end) injury crashes.

3 What rules and regulations do systems need to comply with?

Dutch vehicles need to comply with European requirements, particularly with those concerning safety and the environment. The requirements are determined by agreement between the EU member states, and may also involve (major) economic interests. This agreement and these requirements lead to safer cars. A Norwegian study [8] arrives at a 4% annual reduction in fatalities and serious injuries, but a higher reduction is also possible. Mid-May 2018, The European Commission proposed a number of new requirements, including an advisory ISA (intelligent speed adaptation), facilitation of an alcohol lock, detection (monitoring) of fatigue and distraction, and an in-vehicle Event Data Recorder [9]. These proposals were based on a study of the cost-benefit ratio of these measures [10].

EuroNCAP (European New Car Assessment Programme) was introduced in 1997 by the European Consumers' Organisation, including the Royal Dutch Touring Club ANWB. It contains additional requirements to increase vehicle safety ratings. Vehicles may score up to five stars for different elements. These elements are: driver assistance systems ('safety assists'), the safety of car occupants, the safety of children as car occupants, and the safety of cyclists and pedestrians. Concerning driver assistance systems, the focus is currently on the operation and effectiveness of intelligent seat belt reminders (SBR), speed assist (a kind of ISA), autonomous emergency brake (AEB, works outside urban areas), and a lane support system [11]. Manufacturers make their cars safer and appear to aspire to maximum EuroNCAP scores for (preferably) all elements. The organisation has announced that, thanks to impact tests, 78.000 lives have been saved [12].

4 What requirements does the ITS/ADAS design have to meet to be safely used, by the elderly as well?

At this time, there are no (national and international) legal design requirements for ADAS and other ITS. There *are,* however, recommendations and general design principles focusing on safe use of ADAS/ITS. The European Commission's recommendations about safe and efficient information and communication systems, dating from 2008 [13], are relevant. *Section 4.3* of these recommendations sums up six groups of recommendations under the heading 'Principles' (overall design, installation, information presentation, interface with displays and control, system behaviour, and information about the system) and *Section 5.2* sums up usage recommendations aimed at, for instance, employers and end-users. It would be taking things too far to mention them all here, but the overall design objectives present an appropriate framework for these principles. They are:

I. The system supports the driver and does not give rise to potentially hazardous behaviour by the driver or other road users
II. The allocation of driver attention while interacting with system displays and controls remains compatible with the attentional demand of the driving situation
III. The system does not distract or visually entertain the driver
IV. The system does not present information to the driver which results in potentially hazardous behaviour by the driver or other road users
V. Interfaces and interface with systems intended to be used in combination by the driver while the vehicle is in motion are consistent and compatible

Annex 5 of a UNECE resolution dating from 2017 [14] gives information about the design principles for ADAS. There are three categories: ADAS that inform, ADAS that warn and ADAS that intervene ('control systems'). The resolution only deals with the latter, divided into four sections.

1. The control element: the requirement that the system intervenes autonomously in case of an inevitable crash, but that the driver may also intentionally ignore the system.
2. The operation: the system is enabled by default, but the driver should also be allowed to turn it off (permanently).
3. The principles for communication by means of the display: this should clearly show drivers whether the system is enabled and when they should take over full control of the vehicle.
4. Additional information/communication elements: elements that remind the driver to be fully alert at all times, et cetera.

Older drivers are known to process information more slowly, to have poorer eyesight and hearing (see the archived SWOV fact sheet *The elderly and Intelligent Transport Systems (ITS)*). Slower information processing implies, among other things, that the elderly may experience some problems if different ADAS are operational at the same time but function independently. Alignment or choice decisions are therefore important. Eyesight and hearing impairment imply that letters should be larger and that information should preferably be visible, audible and tangible at the same time and that the timing of the information should be attuned to the user's reaction time. Since the capacities and limitations of the elderly differ greatly, customization is the ideal solution, which intelligent systems should be able to facilitate. In addition, it is important that ADAS applications should not only be tested by young drivers, but also by older ones. If older drivers are able to perform a task safely and with hardly any trouble, other drivers should be able to do so as well [15].

5 What are possible disadvantages of ITS and ADAS?

The European Commission points to the following possible disadvantages of ITS and ADAS: distraction, triggering hazardous behaviour and confusion [13]. Thus, it is unwise to set the navigation system while driving, to have a small (navigation) screen positioned far aside from the driving direction forcing prolonged glances away from the road, etcetera. It may also be confusing when an intelligent speed assistant indicates an incorrect (for example temporary) speed limit. If part of a driving task, for example changing lanes, is taken over, this should happen in a natural way – similar to the way a human driver would operate – so as not to confuse other road users.

A further area of concern is the 'transfer of control'. When a system fails or does not (yet) function in a particular situation, the driver must know that he should take over control. This requires appropriate and timely communication with the driver (also see the design principles of UNECE dating from 2017 [14]).

Not much is known about the (incorrect) use of systems. Studies into the effects, based on (prevented) crashes, have been done, but these mostly concern the presence of a system. It is usually not known whether the system was enabled nor, more importantly, how it was used. In Naturalistic Driving studies however, drivers are followed by cameras, among other things, which means that the way systems are used *can* be determined. An extensive American Naturalistic Driving study [16] also found a sufficient number of crashes to allow saying something about the risk of operating devices in cars. Operating of devices such as the airconditioning and the radio occurred in, respectively, 0.56% and 2.21% of the distance travelled. Operating a system while driving was part of the residual category of 0.83% of the distance travelled. The 4.6% risk (odds ratio) of this residual category proved to be significantly higher than that of operating the airconditioning (2.3) and the radio (1.9). The 4.6 risk means: 4.6 times more crashes per distance travelled than average.

People adapt their behaviour to (changing) circumstances - a road safety measure that has been implemented for example. This is called behavioural adaptation [17]. This implies that the hypothetical effect of measures such as ITS/ADAS will, in actual fact, turn out differently [18]. Thus, the presence of a night vision system may tempt drivers to drive (faster) in the dark more often than without such a system, which will (partly) annihilate the potential benefit. It is therefore essential to monitor the actual effects and to adapt the system accordingly.

6 How often do people use ITS/ADAS provisions in their vehicles?

A study among 1355 business drivers into the use of seven ITS/ADAS provisions [2] showed that four of them were hardly ever used. An important reason for not using them is that the drivers were not aware of their cars being equipped with these provisions. *Figure 1* shows presence and usage of the provisions.

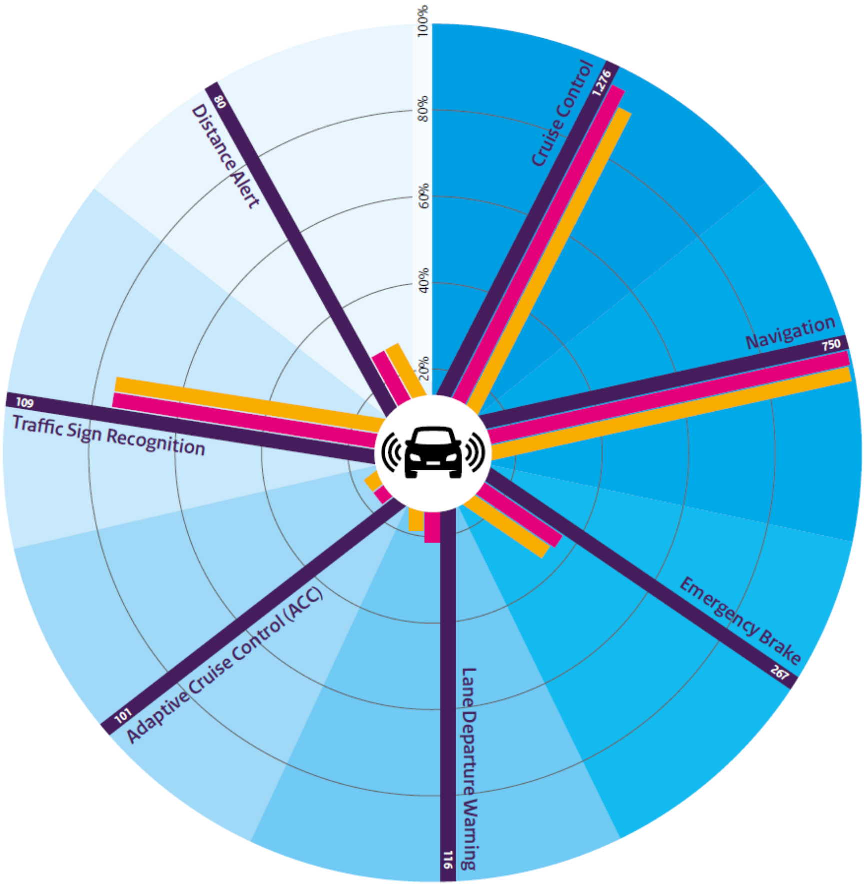

Figure 1. Presence of (dark blue), awareness of (pink) and usage of (yellow) ITS/ADAS for business drivers (Source: [2]).

Cruise control (1276 of 1355) and integrated navigation (750) are common systems, which is apparent from awareness and usage: almost all respondents knew that the system was present in their cars and indicated using it. Emergency Brake was much less familiar (267) and fewer than half these respondents knew the system was available and 'used' it (in so far as 'use' is the appropriate word for this autonomous system). Fewer than one in ten of the business drivers questioned reported the presence of Lane Departure Warning, Adaptive Cruise Control, Traffic Sign Recognition or Distance Alert. Only very few were aware of the presence of these systems in their cars and used them. An exception was Traffic Sign Recognition, which a large majority knew and reported having used. The researchers conclude:

"The lack of awareness of ownership of ADAS currently appears to be the largest bottleneck for the breakthrough of ADAS usage. […] many drivers are not aware with which ADAS their car is equipped. When drivers are aware of owning a specific system they appear to be likely to use it. Even though it is not said that an increase of awareness of ADAS ownership will result in an equal increase in ADAS usage, it is, however, expected that stimulating awareness of ADAS ownership will result in increased ADAS usage."

For the systems mentioned above, the lack of awareness and usage is not that serious with respect to road safety. The most relevant system is Emergency Brake which functions autonomously and therefore independently of the driver. The other systems are mainly driver comfort systems which may be expected to have only a limited effect on road safety. More relevant is that, for business drivers, systems specifically aimed at road safety are scarce, with the exception of Emergency Brake.

7 What is (Cooperative) Adaptive Cruise Control (C-ACC) and what is its effect on road safety?

Adaptive, or Advanced, Cruise Control (ACC) not only maintains a steady speed as is usual with Cruise Control, but also measures the headway or headway time to the vehicle in front. When this headway or headway time gets too short, the car itself will reduce speed. ACC may also respond to changes in headway time and calculate the so-called time-to-collision, or the time-to-collision if no actions are taken. This is, in fact, similar to the principle of a Forward Collision Warning system (FCW), different in so far as an FCW sends an alert while an ACC itself intervenes by reducing speed.

Cooperative ACC (C-ACC) implies that the car communicates with other cars and knows whether the cars in front of it are reducing speed. A major benefit is that traffic flow becomes more stable and the number of shock waves is reduced. Shock waves may lead to rear-end collisions. C-ACC is already being tested, but is not on the market yet.

ACC is a driver comfort system that in itself does not or does only slightly affect road safety. An inventory of studies into the effects of ACC shows that an unambiguous conclusion about its effectiveness cannot be arrived at [19]. A cost-benefit analysis [10] shows that the costs are expected to be higher than the benefits. It is noted, however, that this ratio may change in combination with Autonomous Emergency Brake (AEB), since a great deal of the costs will already have been made for AEB (same technology). The combination of ACC (or FCW) and AEB resulted in a major reduction (approximately 40%) in rear-end injury collisions; Solitary ACC only resulted in a reduction of PDO crashes (Property Damage Only) [7].

8 What is Intelligent Speed Adaptation (ISA) and what effects does it have on road safety?

Intelligent Speed Adaptation (ISA) is a system that compares vehicle speed to the speed limit or to the required speed. It informs or warns the driver, or intervenes if the driver drives too fast. This prevents high speeds, one of the main crash factors (also see SWOV fact sheet Speed and speed management).

ISA has become a proven technology highly recommended by other organisations including the European Transport Safety Council [20]. In 2004, a study in 23 European countries demonstrated ISA's appeal: 59% supported the system, with the Netherlands scoring 51%. Among Dutch interest groups from industry, road users, public authorities etcetera, the informative ISA appeared to be the most popular among 18 safety provisions [22]. In 2018, the European Commission proposed making a haptic (touch sensitive) version of ISA mandatory [9]: "It shall be possible for the driver to feel through the accelerator pedal that the applicable speed limit is reached or exceeded." The effect of ISA types differs: a mandatory intervening ISA the largest effect, an advising ISA the smallest. The effect also depends on the type of speed limit. Effects are largest in case of dynamic limits, meaning limits that are dependent on the actual weather and traffic conditions. Furthermore, ISA has a larger effect on the more serious crashes, as shown by *Figure 2*.

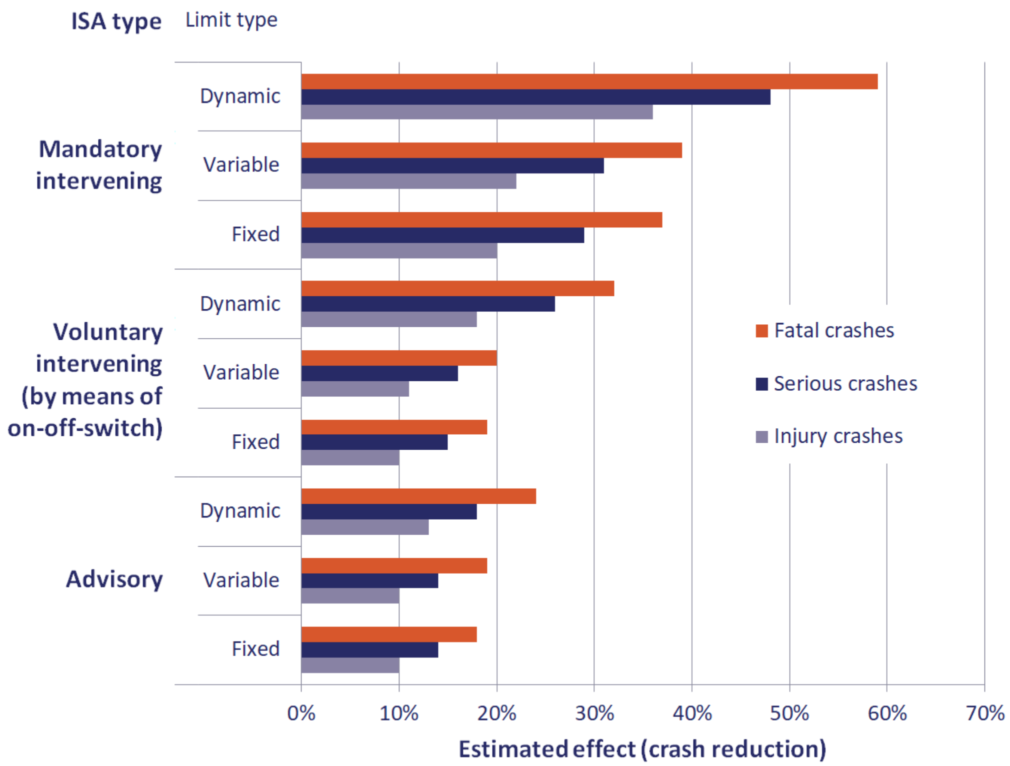

Figure 2. Most reliable estimation of crash reduction by ISA type (mandatory intervening, voluntary intervening (driver-select) or advisory) and speed limit (fixed, variable or dynamic) [23]

A survey by Vlassenroot [24] among 7000 Belgian and Dutch participants found that approximately half of them would like to have ADAS and almost all of them would like some form of ISA. Informative ISA is preferred by 30%, the warning type by 38%, while 12% prefers the supportive ISA and 15% the intervening ISA. The supportive type scores remarkably poorly and Vlassenroot suspects that the participants are unsure about what the different types mean. The haptic type proposed by the EU – which Vlassenroot would probably call 'supportive'- is not mandatory but goes slightly further than a mere 'advisory' type. Moreover, these will concern fixed speed limits or, possibly, time-bound variable limits. For a successful introduction, a reliable digital map containing these limits is needed. GPS positioning should be able to distinguish between the road the driver is travelling on and adjacent roads, for instance a service road adjacent to a motorway.

9 What is an alcohol lock and what effect does it have on road safety?

When using an alcohol lock, the driver has to breathe into a breath analyzer, in the same way as required during alcohol checks by the police. When the blood alcohol content is too high, the driver will not be able to start the car. For verification, the driver also has to breathe into the device while driving. In 2018, the European Commission proposed equipping all new cars with an interface for fitting an alcohol lock [9]. After all, alcohol consumption by road users is still one of the main crash factors. An alcohol lock programme would result in a 65-90% reduction of the recidivism rate, at any rate for the duration of the programme (also see SWOV fact sheet *Driving under the influence of alcohol*). When, however, an alcohol lock is combined with an extensive programme not only dealing with the symptoms but also with the causes of the alcohol problem, this combination may lead to permanent changes in both alcohol consumption and driver behaviour [25] [26]. The price of an alcohol lock (programme) is rather high and this is seen as an impediment. The EU proposal may, on account of economies of scale, lead to lower costs and will make it easier, for employers for example, to include an alcohol lock in their company policies or safety cultures.

10 What is Lane Departure Warning (LDW) and what effect does it have on road safety?

A Lane Departure Warning (LDW) system measures the distance to the lane lines and warns drivers if they drift towards these lines too closely or too fast. The system assists in lane keeping for example by monitoring length (axis or edge) markings by means of a camera. Good-quality markings are essential to reliable functioning of the system. Warnings may be auditory or may be given by means of a steering wheel signal (haptic). There are also Lane Keeping Systems (LKS), that autonomously correct the direction of the car. Almost one third of all registered road deaths

(2005-2009) are road shoulder crashes (see the archived SWOV fact sheet *Run-off-road crashes*). An unknown share of head-on (multiple) collisions is the result of a manoeuvre by the driver to steer back to the centre of the road but oversteering to the wrong side of the road. A system preventing cars from veering off the road could therefore be very effective.

A study for the European Commission into the costs and benefits of new vehicle technologies [10] concludes that making LDW for cars and delivery vehicles (category M1/N1) mandatory should not be recommended: the costs are expected to outweigh the benefits of prevented crashes. In various studies, positive effects of LDW are expected, but Hynd et al. [10] discuss an American study based on field data which does not show any crash reduction. That is why the cost/benefit calculation assumes the absence of any effect. For trucks and buses (categories M2,3 and N2,3) Hynd et al. arrive at a slightly higher maximum effect of LDW. Jänsch [27] concludes that the effectiveness of LDW remains unclear.

In addition to the warning LDW system, there are also interventionary, redirecting Lane Keeping Systems (LKS). For these systems, the benefits are expected to outweigh the costs [10]. These expectations are partly based on the American study discussed by Hynd et al. [10] which indicate a positive effect of this system in actual traffic. Hynd et al. do, however, draw attention to the potential problem of acceptance among users.

Presumably and partly based on these findings, the European Commission has, for its new regulations concerning type approval of motor vehicles [9], proposed making an interventionary LKS mandatory for cars and delivery vehicles and a warning LDW system for lorries and buses.

11 How do Autonomous Emergency Brake (AEB) systems work and what effects do they have on road safety?

An Autonomous Emergency Brake (AEB) system is an emergency brake system that intervenes autonomously when (after several warnings) the driver does not apply the brakes. Maximum brake delay is applied, which means more braking force is used than the driver usually applies. In this way, crashes may be prevented or injury severity may be mitigated on account of a lower collision speed. Two types of AEB systems may be distinguished: a system that merely responds to the presence of other cars and a system that also responds to the presence of cyclists and pedestrians. The first uses radar for example, the second uses (smart) cameras.

Both the effectiveness of an AEB system [28] [29] and the cost-benefit ratio [10] are assessed positively. A study into the effectiveness, based on crashes in several European countries, showed a 38% reduction of rear-end collisions [30]. The European Commission has included AEB systems in its proposals for revised type approval [9].

AEB systems do not always work flawlessly, for instance because the software has trouble recognizing an image or because a sensor (radar, camera) simply cannot see everything. When a system alerts the driver or intervenes, the chances of unjustly alerting or intervening (false positive) or unjustly not alerting or intervening (false negative) should be balanced against each other. In the case of alerts, occasional unnecessary warnings are less serious, as long as the system remains credible. Better one too many than one too few warnings; it is, after all, the driver who remains in control. In case of an intervening system, groundless abrupt braking is objectionable; it may lead to dangerous situations, especially in the presence of following traffic. This will more likely result in the choice not to intervene when intervention *was* called for. Moreover, if a system regularly makes mistakes, drivers will switch it off. Sensors and software continuously improve however, which will decrease the number of mistakes and increase the effectiveness of autonomous (intervening) systems in particular. To enable fully self-driving cars, such systems should comply with very strict requirements, which means they are only expected to arrive in a few decades [31]. Meanwhile, the improvement of existing ADAS, such as AEB systems, may greatly increase safety.

12 What effects do navigation systems have on road safety?

No extensive research into the effects of navigation systems on crash risk has been done; firm conclusion about effectiveness may therefore not be drawn (see the archived SWOV fact sheet *Safety effects of navigation systems*). A survey among Dutch lease car drivers [32] showed that the group with a navigation system had 10% less crashes for the distance travelled and claimed 5% lower costs (per crash).

Theoretically, there are both advantages and disadvantages. Better navigation implies fewer detours and less traffic exposure. Searching is no longer necessary, which means more attention may be paid to traffic. Drivers know when they will arrive, which leads to less stress. But if destinations are set during driving, or if the screen is in an awkward position, distraction will in fact increase. If drivers are directed from safe motorways to less safe secondary roads, this will be detrimental. The same goes when the digital map is inaccurate or no longer accurate. The share of car drivers with a navigation system is high (also see the question *How often do people use ITS/ADAS provisions in their vehicles?*).

13 How does eCall work and what effects does it have on road safety?

An eCall system will automatically contact the emergency number 112 immediately after a crash, and the dispatcher will contact the occupants. In that way, the crash severity may be assessed and the proper emergency services will be sent [33]. An EU infographic about the interoperable EU-wide eCall explains this.

The advantage of eCall is that emergency services will generally be warned sooner when casualties are unable to do so themselves or when there are no bystanders or other road users to make the call. Previously, Schoon et al. [6] estimated the effect in the Netherlands to amount to a 2% reduction in the number of fatalities and serious injuries if all cars were equipped with eCall. This is in line with the 5 to 10 fewer road deaths expected by the Ministry of Justice and Security [34]. The system has been mandatory for all new types/models of cars and delivery vehicles since 1 April 2018 [35]. The number of vehicles currently equipped with the system is unknown. Schoon et al. [6] estimate that six years after the introduction of the legal requirement 48% of the cars will have eCall.

14 How do night vision systems work and what effects do they have on road safety?

In poor visibility (fog, darkness), the crash risk is (much) higher. A night vision system, making use of radar or infra-red cameras, can project an improved image on the windscreen. This system has existed for some time (more than 15 years) in higher-end models, but has not yet penetrated the lower-end market segment (on account of the price of the system) [10]. The usually rather small-scale simulator studies generally show a positive effect on driving performance in the dark (for example [36] [37]). As far as we know, and probably because of the low numbers, no research has been done based on (prevented) crashes. According to an effect assessment for Germany (eSafety Forum, 2005 in [10]), based on a penetration of 70%, 17.5% of the crashes between cars and cyclists or pedestrians in conditions of poor visibility could be prevented. This amounts to 0.1% of all crashes. Moreover, there is some concern that the positive effects will, in actual traffic, be (partly) cancelled out because of the distraction caused by the projected image, or because of behavioural adaptation (for instance because of driving faster; also see the question *What are possible disadvantages of ITS/ADAS?*) [10].

15 How do vehicle data recorders work and what effects do they have on road safety?

Cars record a lot of data that are read by car dealers/garages (in particular for maintenance) to check whether there are any defects. Today, most cars are also equipped with an OBD (On Board Diagnostics) interface which allows all kinds of information to be read by anyone. The interface is used, for example, for connecting a so-called dongle, a device that can send data via a (mobile phone, 4G) network. The data may be processed centrally into information that may be sent back to the driver. So drivers can see whether and how often they brake abruptly, drive too fast, use a lot of petrol etcetera. Employers have been using these systems for much longer, particularly in those sectors in which safety has traditionally been very important, such as the energy sector or chemical industry (see for example The Network of Employers for Traffic Safety NETS). After all, on public roads their employees run the greatest risks. The measured road user behaviour is discussed and has consequences for financial rewards for instance or, in the case of serious offences, employees' engagement. These services are also available to private individuals (see for example ANWB Connected).

The effect of this kind of data recorder strongly depends on the consequences arising from appropriate or inappropriate road behaviour, both positive consequences (fuel efficiency, increased safety, financial rewards) and negative ones (lower/no bonus, dismissal). For example: in 2005, for lorry drivers a 20% crash reduction was found, while for young drivers there were no consequences and therefore no effects [38]. By contrast, a study among youngsters dating from 2017 did find large effects of feedback on behaviour measured by data recorders: a reduction of up to and over 50% in hazardous events [39].

The abovementioned data recorders measure daily usage. There are also data recorders that only record data immediately prior to, during and after a crash (EDR, Event Data Recorders). Those data are initially particularly important to know what went wrong and what measures could be taken to prevent this kind of crash or to mitigate the consequences. The effect of an EDR on road safety is therefore indirect: it mainly leads to more knowledge about crash factors. This application does not affect driver behaviour itself. It might do so – but this has yet to be proven – if there are (criminal litigation) consequences [40].

Publications and sources

Below you will find the list of references that are used in this fact sheet; all sources can be consulted or retrieved. Via Publications you can find more literature on the subject of road safety.

[1]. European Commission (2016). *Advanced driver assistance systems*. European Commission, Directorate General for Transport.

[2]. Harms, I.M. & Dekker, G. (2017). *ADAS: from owner to user; Insights in the conditions for a breakthrough of Advanced Driver Assistance Systems*. Connecting Mobility.

[3]. McDonald, A., Carney, C. & McGehee, D.V. (2018). *Vehicle owners' experiences with and reactions to Advanced Driver Assistance Systems*. The University of Iowa, Iowa City, Iowa.

[4]. Lai, F., Carsten, O. & Tate, F. (2012). *How much benefit does Intelligent Speed Adaptation deliver: An analysis of its potential contribution to safety and environment*. In: Accident Analysis & Prevention, vol. 48, p. 63-72.

[5]. Yue, L., Abdel-Aty, M., Wu, Y. & Wang, L. (2018). *Assessment of the safety benefits of vehicles' advanced driver assistance, connectivity and low level automation systems*. In: Accident Analysis & Prevention, vol. 117, p. 55-64.

[6]. Schoon, C.C., Reurings, M.C.B. & Huijskens, C.G. (2011). *Verkeersveiligheidseffecten in 2020 van maatregelen op het gebied van de veiligheid van personenauto's. Effectschatting van primaire, secundaire en tertiaire veiligheidsvoorzieningen*. R-2011-18. SWOV, Leidschendam.

[7]. IIHS (2016). *Crashes avoided. Front crash prevention slashes police-reported rear-end crashes*. In: Status Report Insurance Institute for Highway Safety, vol. 51, nr. 1.

[8]. Høye, A. (2017). *Road safety effects of vehicles crashworthiness, weight, and compatibility*. English summary with TØI Report 1580. TØI, Oslo.

[9]. European Commission (2018). *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users, amending*

Regulation (EU) 2018/… and repealing Regulations (EC) No 78/2009, (EC) No 79/2009 and (EC) No 661/2009. COM/2018/286 final - 2018/0145 (COD). European Commission, Brussel.

[10]. Hynd, D., McCarthy, M., Carroll, J., Seidl, M., et al. (2015). *Benefit and feasibility of a range of new technologies and unregulated measures in the field of vehicle occupant safety and protection of vulnerable road users : final report.* Catalogue number NB-07-14-108-EN-N. European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Brussel.

[11]. EuroNCAP (2019). *De beoordelingen nader verklaard. Safety Assist*. Retrieved on 18 February 2019 at https://www.euroncap.com/nl/veiligheid-voertuig/de-beoordelingen-nader-verklaard/safety-assist/.

[12]. Ratingen, M. van (2018). *Euro NCAP botsproeven hebben meer dan 78.000 mensen gered*. RAI en SWOV. Retrieved on 28 November 2018 at https://veiligonderwegmetdeauto.nl/artikelen/michiel-van-ratingen.

[13]. EU (2008). *Aanbeveling van de Commissie betreffende veilige en efficiënte informatie- en communicatiesystemen aan boord van voertuigen: bijwerking van de Europese verklaring inzake beginselen voor de mens-machine-interface (Kennisgeving geschied onder nummer C(2008) 1742)*. 2008/653/EG. Europese Unie.

[14]. UNECE (2017). *Consolidated Resolution on the Construction of Vehicles (R.E.3); Revision 6*. Resolution ECE/TRANS/WP.29/78/Rev.6. United Nations, Economic Commission for Europe.

[15]. Davidse, R.J. (2004). *Ouderen en ITS: samen sterk(er)? Literatuurstudie naar de toegevoegde waarde van intelligente transportsystemen voor de veiligheid van de oudere automobilist*. R-2003-30. SWOV, Leidschendam.

[16]. Dingus, T.A., Guo, F., Lee, S., Antin, J.F., et al. (2016). *Driver crash risk factors and prevalence evaluation using naturalistic driving data*. In: National Academy of Sciences of the United States of America PNAS. Volume 113, p. 2636-2641.

[17]. Rudin-Brown, C. & Jamson, S. (2013). *Behavioural adaptation and road safety: theory, evidence and action*. press CRC.

[18]. Smiley, A. (2000). *Behavioral adaptation, safety, and intelligent transportation systems*. In: Transportation Research Record, vol. 1724, nr. 1, p. 47-51.

[19]. Reed, S. (2017). *Adaptive Cruise Control*. European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved on 11 December 2018 at www.roadsafety-dss.eu.

[20]. ETSC (2017). *Briefing: Intelligent Speed Assistance (ISA)*. European Transport Safety Council ETSC. Retrieved on 18 February 2019 at https://etsc.eu/briefing-intelligent-speed-assistance-isa/.

[21]. SARTRE (2004). *European drivers and road risk. Project on Social Attitudes to Road Traffic Risk in Europe SARTRE 3. Part 1: report on principal results*. Institut National de Recherche sur les Transports et leur Sécurité INRETS, Arcueil, France.

[22]. Aarts, L., Eenink, R. & Weijermars, W. (2014). *Opschakelen naar meer verkeersveiligheid; naar maximale verkeersveiligheid voor en door iedereen*. R-2014-37. SWOV, Den Haag.

[23]. Carsten, O.M.J. & Tate, F.N. (2005). *Intelligent speed adaptation: accident savings and cost–benefit analysis*. In: Accident Analysis & Prevention, vol. 37, nr. 3, p. 407-416.

[24]. Vlassenroot, S. (2011). *The acceptability of In-vehicle Intelligent Speed Assistance (ISA) Systems: from trial support to public support*. TRAIL Thesis Series T2011/8. Trail Research School.

[25]. Bjerre, B. & Thorsson, U. (2008). *Is an alcohol ignition interlock programme a useful tool for changing the alcohol and driving habits of drink-drivers?* In: Accident Analysis & Prevention, vol. 40, nr. 1, p. 267-273.

[26]. Gustafsson, S. & Forsman, A. (2016). *Utvärdering av alkolås efter rattfylleri: enkätstudie [Evaluation of a Swedish alcohol interlock program for drink driving offenders: questionnaire study]*. VTI-code: 35-2016; summary in English. VTI, Linköping.

[27]. Jänsch, M. (2017). *Lane keeping systems*. European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved on 11 December 2018 at https://www.roadsafety-dss.eu.

[28]. Saadé, J. (2017). *Autonomous Emergency Braking AEB (city, inter-urban)*. European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved on 11 December 2018 at https://www.roadsafety-dss.eu.

[29]. Saadé, J. (2017). *Autonomous Emergency Braking AEB (pedestrians & cyclists)*. European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved on 11 December 2018 at www.roadsafety-dss.eu.

[30]. Fildes, B., Keall, M., Bos, N., Lie, A., et al. (2015). *Effectiveness of low speed autonomous emergency braking in real-world rear-end crashes*. In: Accident Analysis & Prevention, vol. 81, p. 24-29.

[31]. Weijer, C. van de (2018). *De file is de beste manier om files op te lossen*. Retrieved on 18 February 2019 at https://veiligonderwegmetdeauto.nl/artikelen/carlo-van-de-weijer.

[32]. Vonk, T., Rooijen, T., Hogema, J. van & Feenstra, P. (2007). *Do navigation systems improve traffic safety?* TNO, Soesterberg.

[33]. Rijksoverheid (2019). *Wat is het systeem eCall in mijn auto?* Retrieved on 18 February 2019 at https://www.rijksoverheid.nl/onderwerpen/alarmnummer-112/vraag-en-antwoord/wat-is-het-systeem-ecall-in-mijn-auto.

[34]. Ministerie van JenV (2018). *Factsheet eCall - automatisch contact met 112 bij een ernstig ongeval*. Ministerie van Justitie en Veiligheid.

[35]. Europees Parlement (2015). *Verordening (EU) 2015/758 van het Europees parlement en de raad van 29 april 2015 inzake typegoedkeuringseisen voor de uitrol van het op de 112-dienst gebaseerde eCall- boordsysteem en houdende wijziging van Richtlijn 2007/46/EG*. Europees Parlement, Brussel.

[36]. Caird, J.K., Chugh, J.S., Wilcox, S. & Dewar, R.E. (1998). *A design guideline and evaluation framework to determine the relative safety of in-vehicle intelligent transportation systems for older drivers*. Transport Canada, Transportation Development Centre TDC, Montreal, Quebec.

[37]. Hollnagel, E. & Källhammer, J.-E. (2003). *Effects of a night vision enhancement system (NVES) on driving: results from a simulator study*. In: the Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design. Park City, Utah. Iowa City, IA, Public Policy Center, of Iowa, p. 152-157.

[38]. Kampen, B. van, Krop, W. & Schoon, C. (2005). *Auto's om veilig mee huis te komen*. SWOV & RAI Vereniging, Leidschendam

[39]. Toledo, T. & Lotan, T. (2017). *Feedback technologies to young drivers*. In: Fisher, D.L., et al. (red.), Handbook of teen and novice drivers. CRC Press, Boca Raton, p. 305-318.

[40]. Hynd, D. & McCarthy, M. (2014). *Study on the benefits resulting from the installation of Event Data Recorders: final report. Report prepared for the European Commission, DG MOVE*. Published Project Report; PPR 707. Transport Research Laboratory TRL, Crowthorne, Berkshire.

Colophon

Reproduction is allowed with due acknowledgement:
SWOV (2019). *Intelligent transport and advanced driver assistance systems (ITS and ADAS)*. SWOV Fact sheet, April 2019. SWOV, The Hague.

URL Source:
https://www.swov.nl/en/facts-figures/factsheet/intelligent-transport-and-advanced-driver-assistance-systems-its-and-adas

Topics:
Technology & ITS

Figures:

Prevent crashes
Reduce injuries
Save lives

SWOV
SWOV Institute for Road Safety Research
PO 93113
2509 AC The Hague
Bezuidenhoutseweg 62
+31 70 317 33 33
info@swov.nl
www.swov.nl

@swov / @swov_nl
linkedin.com/company/swov