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Safety and the Use of Smart Driver Assistance Systems

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Abstract:

Purpose: *The article discusses the safety systems implemented in road vehicles, their impact on the driving of a car by the driver as well as the related risks and problems.*
Design/Methodology/Approach: *The proper study was focused in the field of smart driver assistance systems. The article uses the methods of source analysis, descriptive analysis and the method of deduction.*
Findings: *The problem of accidents is not directly related to the safety systems used in vehicles, but can be solved by them. Vehicle-mounted solutions often save lives and reduce accidents. However, it should be remembered that they will not replace the driver in the decision-making process for now.*
Practical Implications: *The results of this study can be used as a starting point for further analysis in the area of the safety systems implemented in road vehicles, their impact on the driving of a car by the driver as well as the related risks and problems.*
Originality/value: *From mid-2022, all brand new cars entering the EU market will have to be equipped with advanced safety systems. The authors of the article focus on the question of how the use of smart driver assistance systems improves the safety of all road users.*

Keywords: *Safety, smart driver assistance systems, active and passive safety system, innovative safety systems, Lane Keeping Assist Systems, Adaptive Cruise Control, night driving assistant, Driver Alert Control, autonomous vehicles.*

JEL classification: *R40, R99.*

Paper Type: *Research study.*

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1. Introduction

Human functioning has always been associated with the necessity of his movement. It is determined by the ability to satisfy human needs by performing everyday activities. Limiting the possibility of movement, and thus satisfying one's own needs, would lead to the collapse of modern civilization. From the point of view of the possibilities of activities of individuals in the economy and society, the movement of people is the most important process (Wyszomirski, 2008).

The dynamic development of the economy of the European community caused problems related to transport and road traffic. The growing demand for transport services and the need to satisfy them forces the search for solutions to improve safety. An efficient and effective transport system should reduce the existing transport problems, mainly in the number of road accidents and collisions (Fletcher, 2009). It is so important that these events have a direct impact on road congestion, which are the source of other problems such as an increase in emissions of pollutants, noise and deterioration of health, the quality of life of residents by limiting their mobility, and thus transport accessibility (https://ec.europa.eu/).

The continuous increase in traffic and the number of vehicles contributes to the need to invest in newer and newer solutions (systems) in the field of safety (Young and Salmon, 2012). Such systems are often the most important element of a vehicle's equipment. Thanks to their operation, it is possible to minimize the adverse effects of road incidents and avoid serious damage to the health of passengers in the vehicle (Salmon *et al.*, 2011). An important issue is their modernization and introduction of new, innovative solutions. Technological progress is one of the main factors reducing the number of road hazards (https://www.consilium.europa.eu/).

The transport policy at the Community level of the European Union, as well as the competition of vehicle manufacturers, force the search for solutions to improve the safety of all road users (https://www.europarl.europa.eu/). The authors of the article focus on the question of how the use of smart driver assistance systems improves the safety of all road users. The subject of the research contained in this paper are selected examples of solutions in the field of safety systems in road vehicles. The subject of research are solutions introduced in the field of smart driver assistance systems. The article uses the methods of source analysis, descriptive analysis and the method of deduction.

2. Passive and Active Safety Systems

"Passive safety is a set of vehicle features aimed at reducing the effects of a collision or road accident from the point of view of all its participants" (https://amp.ww.pl.freejournal.org/). Virtually every vehicle that travels on the road is equipped with standard elements classified as passive systems shown in Figure 1 (Brill and Łukasik, 2013):

- airbags,
- seat belts with pretensioners,
- appropriate body structure responsible for the maximum dissipation of energy from a collision,
- child seats,
- headrests,
- articulated steering column.

Figure 1. *Passive safety systems*

Source: *https://www.acea.auto/*

These are the elements that are designed to provide maximum protection against the consequences of an accident. They are aimed at protecting the driver and passengers in the event of a road collision, minimizing adverse effects, e.g., by absorbing the force of an impact against an obstacle and maintaining the correct position of the vehicle user (Morris *et al.*, 2010). These systems have so far saved millions of people around the world. However, you should remember about their correct use (Prochowski and Żuchowski, 2006).

Active safety, on the other hand, is those elements of a car's equipment or structure, the task of which is to prevent an accident or a collision. They are therefore to actively participate in the fact that drivers and passengers were not hurt (https://media.daimler.com/). They have a significant impact on the driver's behavior, acceleration of his decisions, reactions to the situation, and help to avoid a collision or a road accident (Reński, 2011). The following active systems are distinguished:

- vehicle construction allowing maximum visibility in the car,
- steering system, suspension and tires, improving adhesion to the ground,
- braking system with brake power steering and control,
- traction control systems (ABS, BAS, ASR most often included in the ESP).

Thanks to the constantly evolving technique and technology, these systems seem to be the future in preventing road accidents and collisions. They perform the function of supporting the driver's decisions, characterized by a very fast process of operation and interaction with other safety systems (https://roadsafetyfacts.eu/).

The operation of these systems is based on the acquisition, analysis and processing of various data generated by sensors placed in the vehicle. Successive generations of vehicles are equipped with an increasing number of such sensors, collecting data on, among others, (Morris *et al.*, 2010):

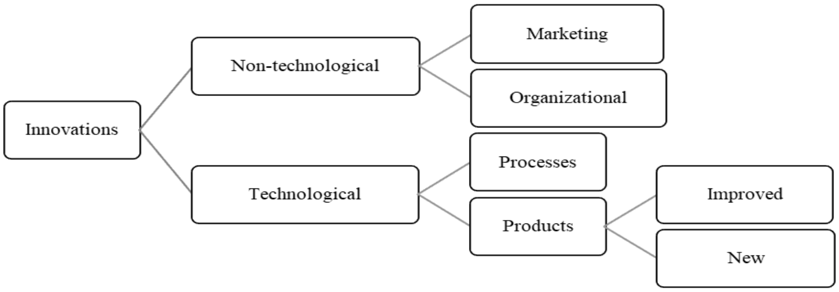
– rotational speed of the wheels,
– air pressure in wheels,
– steering angle,
– brake fluid pressure,
– suspension level,
– operation of the differential system,
– rotational speed around the vehicle axis,
– the current speed of the vehicle,
– current torque transmitted to the wheels,
– speed of pressing the brake pedal,
– gear ratios,
– number of passengers,
– engine temperature,
– baggage weight, etc.

On their basis, the optimal parameters of individual vehicle systems and its current behavior are calculated, weather conditions are determined and their influence on the selected driving path. The torque, speed and braking force of individual wheels are regulated in an emergency (e.g., during sudden braking on a bend or on a slippery surface). These systems are constantly being upgraded first and foremost to increase their ability to operate and adapt to changing road conditions (Spyropoulou *et al.*, 2008).

3. Innovative Safety Systems

So far, there is no uniform definition of innovation and there are no uniform criteria for their division. The basic classification of innovations is included in the *Oslo Manual* prepared by the OECD (OECD and Eurostat, 2006). The division proposed there (Figure 2) indicates the separateness of activities of a technological (processes and products) and non-technological (marketing and organizational innovations) nature.

Figure 2. *Classification of innovations*



Source: *Own study based on: Podręcznik Oslo. Zasady gromadzenia i interpretacji danych dotyczących innowacji, Ed. 3, OECD and European Commission (Eurostat), Warsaw 2006, pp. 19-20, 47-50.*

The aim of innovation is, on the one hand, to make better use of the existing potential and, on the other hand, to create new one. Transport is characterized by high innovation susceptibility, but it is limited by the high costs of implementing innovations, as well as the usual fear of decision-makers about implementing innovative solutions that have not been proven anywhere (Janczewski and Strzelczak, 2009).

The development of technology and computerization have a great impact on many areas of life. Therefore, they could not be missing also in the field of motorization. Vehicle manufacturers place newer and newer solutions in their vehicles that improve safety (treated as a priority), improve comfort and freedom of travel (Ibáñez *et al.,* 2017). Innovative solutions, such as the Lane Keeping Assist Systems (Figure 3) system, designed to warn the driver about an unintentional change of the track, are based on data from infrared sensors, lasers and cameras located in the vehicle. On their basis, the system's specialized software starts the process of assisting the driver by alerting him via (https://www.vda.de/):

– steering wheel vibration,
– acoustic and optical signals,
– slight steering wheel movements to get you back on track.

Unfortunately, this system has disadvantages. It should be noted that it needs relatively straight road sections for optimal operation. When negotiating sharp bends, the sensors may not be able to recognize the lane boundaries. The system is also inactive when there is no or poor road markings (Pérez *et al.,* 2017).

Another solution belonging to this class of systems is *Adaptive Cruise Control*, in which the main element is a radar located in the vehicle (https://www.bmw.de/).

This solution is a modernized cruise control, i.e. a system that allows you to maintain a certain predetermined speed (https://www.bosch-mobility-solutions.com/en/). In a situation where a vehicle equipped with active cruise control approaches the object in front with too high speed, the system will assess the situation and slow down or stop the vehicle completely (Figure 4).

Figure 3. *System Lane Assist*

Source: *Own study based on safety systems test in a BMW 530 (G31) xDrive Touring*

Figure 4. *System Adaptive Cruise Control*

Source: *Own study based on a safety systems test in a BMW 530 (G31) xDrive Touring*

It is also possible for the system to start moving again or to speed up once the threat has passed (Bageshwar *et al.*, 2004). The ACC system also works with the ESP, ABS and ASR systems. It should be noted that, like other systems, this one has advantages and disadvantages as described in Table 1 (Pananurak *et al.*, 2009).

Table 1. *Advantages and disadvantages of active cruise control*

Advantages	Disadvantages
– Increased security, – Speed control, – Driving economy, – High driving comfort, – Integration of security systems, – Vehicle environment control.	– Lowers driver alertness, – Works only with automatic gearbox, – Susceptibility to weather conditions, – Problems with detecting cyclists and pedestrians, – Equipment price, – Optimal on straight stretches of road.

Source: *Own study.*

Innovative solutions also include the so-called night driving assistant, i.e., a system whose main task is to improve safety in conditions of limited visibility (Figure 5).

Figure 5. *System Night Vision Camera BMW*

Source: *https://www.youtube.com/*

This system is based on the technology of thermal imaging cameras that allow you to see invisible objects to the naked eye at night, e.g., people, animals or other cars. Thanks to this solution, the driver is able to see objects, e.g. on the roadside, much earlier than with the help of external car lighting[3]. Work on this system is carried out by an increasing number of manufacturers who have noticed that one of the main causes of accidents is the failure to notice the danger in such conditions[4].

The high number of accidents is also caused by driver fatigue. The reason may be, for example, the number of hours spent traveling (usually without rest). The solution supporting in such situations is the so-called Driver Alert Control, i.e. the system responsible for analyzing the driver's condition and reacting in the event of (Stanton and Salmon, 2009):

- driving a vehicle in an uncontrolled manner,
- signs of fatigue or fainting.

The system includes cameras monitoring the driver's condition shown in Figure 6 (eye movement, blinking speed, etc.), cameras controlling the car's surroundings (distance from other vehicles, distance from the edge of the lane) and sensors (e.g., from the suspension and drive system).) generating data processed on an ongoing basis by the on-board computer (Jermakian, 2011). When the limit values are exceeded, the driver is warned with an acoustic signal and a graphic message (Krishnan *et al.*, 2001).

Figure 6. *The Driver Attention Camera with Active Cruise Control*

Source: *Own study based on safety systems test in a BMW 530 (G31) xDrive Touring*

The introduction to the offer of cars equipped with elements improving safety did not result in a drastic decrease in the number of accidents and fatalities (Figure 7). The statistics show a downward trend, but it is not as large as assumed. One of the

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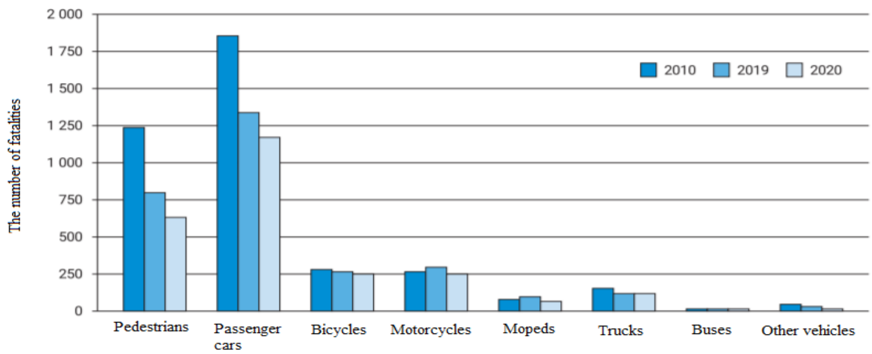
[3]*https://www.springerprofessional.de*
[4]*https://www.adac.de*

reasons for this may be drivers' overconfidence in systems that were supposed to affect comfort and, above all, driving safety, and in many cases led to a reduction in the level of concentration (https://www.adac.de/). Another reason is the increase in the number of vehicles, urban areas and the increase in traffic. The more people use vehicles, the greater the risk of road accidents (Larsson *et al.*, 2010). The most common causes of accidents include:

- intoxication,
- speed mismatch to the road situation,
- incorrect overtaking,
- driver fatigue,
- enforcing the right of way,
- not keeping a safe distance.

Figure 7. *Fatalities of road accidents by means of transport in Poland in 2010, 2019, 2020*



Source: *http://www.obserwatoriumbrd.pl/*

The following years and legal regulations bring a greater number of cars equipped with safety improvement systems. For citizens, this means an increase in security and hence a tendency to place too much trust in these systems. It is the drivers of roadworthy vehicles, equipped with a large number of electronic assistance systems, most often exceeding the permissible speed and causing the most dangerous road situations. Older drivers drive more carefully considering their condition and equipment (Fletcher, 2009). Therefore, the question arises whether it would not be worth taking the burden off the driver and replacing him in the process of driving. Thanks to the novelty in the field of computer science and mechanics as well as many years of testing and research, the so-called autonomous vehicles, as in Figure 8 (Regan, 2005).

There are two categories of such vehicles, the current regulations in Europe refer to (https://eur-lex.europa.eu/):

– fully automatic vehicles, equipped with technology that enables the driver to delegate some of the driving responsibilities to the on-board systems.
– autonomous vehicles equipped with technologies that allow the system to perform all driving functions without any human intervention.

Figure 8. *Autonomous Google vehicle*

Source: *https://www.bbc.com/*

Another classification is that defined by the NHTSA (National Highway Traffic Safety Administration), according to which vehicles are divided into (https://www.nhtsa.gov/):

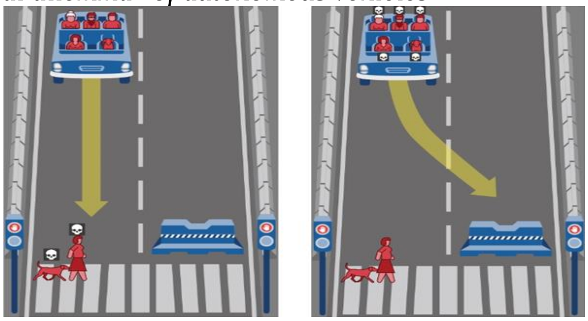
– Level 0 - the driver operates all on-board systems (brakes, gas, steering, etc.).
– Level 1 - Automation of Selected Systems - The driver still operates all systems, but some of them are additionally assisted or can activate independently, eg ESP, ABS, automatic braking.
– Level 2 - the joint operation of the automated systems, relieving the driver of the need to operate them, e.g. adaptive cruise control and lane keeping system.
– Level 3 - the so-called "Self-propelled automation" - the system at this level is able to take full control of the vehicle. The driver still has to "check" the system operation from time to time. However, he does not have to take over the steering wheel immediately.
– Level 4 - high level of automation; the car is able to take control of all aspects of driving, even if the driver does not respond to the call to take control (the computer supports systems for changing lanes, using turn signals or deciding the best time to turn at an intersection).
– Level 5 - full autonomy - the driver is responsible only for entering the destination address, after which he does not have to supervise the system operation for a while during the journey.

The autonomous vehicle management system is based on visual data (cameras installed in the car), data from ultrasonic sensors detecting objects on the road and radar responsible for observing the road under limited external conditions. Despite the many sensors and the large amount of data collected, the rapid development of such vehicles blocks several serious problems, incl. (https://www.synopsys.com/):

- weather affecting the operation of sensors,
- unpredictable behavior of pedestrians
- change in traffic organization caused e.g. by road works,
- legal situation and liability in the event of a conflict.

The most controversial are the solutions to the last problem. The laws of some countries do not allow a situation where a moving vehicle will not be driven by a person licensed to drive that vehicle. This is to ensure the safety of all road users. It seems even more difficult to solve the problem of determining liability in the event of an accident. The computer system driving the car does not distinguish between ethical rules governing road traffic. It analyzes the traffic situation in accordance with the implemented algorithm (https://www.europarl.europa.eu/). However, it is not clearly stated how such an algorithm will select the "more favorable" solution in a potential accident (Figure 8).

Figure 8. *"The moral dilemma" of autonomous vehicles*



Source: *https://www.transport-publiczny.pl/*

The problem of responsibility for a collision (often with a fatal outcome), whether the vehicle user or the designer of the algorithm controlling the vehicle will be convicted, has still not been resolved. That is why such algorithms are constantly improved, and the data needed for their operation is provided by people themselves, who play the role of experts and research objects. According to forecasts, optimally operating autonomous systems will reduce the risk of accidents by 90% (https://www.vtpi.org/avip.pdf).

4. Benefits from Implementing Smart Transport Systems

Currently, there is a dynamic development of the structure in terms of improving the safety of users and the immediate environment of vehicle operation. In the perspective of the next dozen or so years, a significant share of this type of vehicles, especially in the richest EU countries, should not raise any doubts. In recent years, changes in the construction of motor vehicles have contributed to an increase in the level of both active and passive safety (https://ec.europa.eu/). This is best illustrated by the statistical data in Table 2 on road accidents in Poland in the years 2018-2020.

Table 2. *Road accidents in Poland in 2018-2020*

Year	Accidents	Fatalities	Injured	Seriously injured	Collisions
2018	31 674	2 862	37 359	10 941	436 389
2019	30 288	2 909	35 477	10 633	455 454
2020	23 540	2 491	26 463	8 805	382 046

Source: *Own study based on: http://www.obserwatoriumbrd.pl/*

Despite the development of the automotive industry and the increase in the number of registered motor vehicles, a significant decrease in the total number of accidents and collisions is visible. Statistics show that there has also been an overall decline in the number of fatalities, injured and seriously injured. Looking for a justification for such a clear annual overall decrease in the number of fatalities on Polish roads in 2020 by over 14% compared to 2019 means that more than 400 people lost their lives. This state of affairs was influenced by the emergence of the COVID-19 epidemic. There has been a global decrease in traffic, resulting from the introduction of restrictions in movement and other economic phenomena (http://www. Observatoriumbrd.pl/).

Numerous studies indicate that humans are the most susceptible element of transport systems to errors in the art of driving vehicles. Therefore, there is a need for intensive work and the development of driver assistance systems that will replace the driver or support him in some activities (https://pokołozero.pl/). Many of these systems are already offered by manufacturers in higher-end vehicles or when selecting the more expensive new car equipment packages. The basis of their operation is a set of lasers, sensors, radars and cameras (Krzyszkowska, 2015). Due to aging models of society and the progress of civilization diseases, the use of smart driver assistance systems that assess the condition of the driver and his reaction while driving makes more and more sense. The systems are already able to make a psychophysical assessment and detect whether the instructor is able to react independently to dangerous situations. This translates into an increase in safety not only of people traveling by car, but also to the improvement of the safety of other road users, including unprotected pedestrians (Piao and McDonald, 2008).

5. Discussion and Conclusion

The article analyzes selected from the available smart driver assistance systems. These are the safety elements on which the Council of the European Parliament reached an agreement and thus adopted a regulation on the general safety of motor vehicles and the protection of vehicle occupants and vulnerable road users.

The problem of accidents is not directly related to the safety systems used in vehicles, but can be solved by them. Vehicle-mounted solutions often save lives and reduce accidents. However, it should be remembered that they will not replace the driver in the decision-making process for now. Trust, which is the basic principle of drivers, is not yet known to computer systems. Vehicle management algorithms are an artificial creation, as perfect as the experts who created them. Mistakes happen and will continue to happen, so users should control driving, especially as they are not fully aware of the limitations of the safety systems in their vehicles.

Each of the analyzed examples requires continuous modernization and implementation of new solutions for smart safety systems in transport, which is the main challenge for European authorities, producers and, above all, engineers who have to face the dynamic process of road transport development. As indicated in the above article, these changes should take place both at the legislative level, which is often associated with the extended implementation time of new solutions, especially in terms of security. Changes in the area of safety in transport systems, however, are not only legislative and technological changes, which constitute a solid basis, above all, for social changes. The changes introduced in the field of the safety of vehicles produced in the EU Community countries force the society to change the existing habits, which are the driving force to implement solutions minimizing the number of road hazards.

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