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Automatization in road transport: a review

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Abstract
In this article automatization of road transport is investigated. In the first chapter relevant international trends were identified. In this paper the research hypothesis is that in the case of automatized road vehicles there is a significant likelihood of endangering human life. Secondly, the history of road safety is shortly described, especially focusing on vehicle design and sweep of system's theory. In the third chapter evolution of drivers' assistance systems were elaborated, emphasizing especially autonomous vehicles. Finally, in conclusion the authors warn that new technological solutions could pose new threats.

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1. Introduction

In the last couple of years, a decrease has been observed in road traffic fatalities in many European and non-European countries. It is essential to reduce fatal road accidents independently from economic or social status. The status of road safety or its performance is often connected to infrastructure (Peden et al., 2004), as well as a vehicle or road user's behaviour (Török, 2017). More detailed investigaions were carried out in some countries showing a connection between a number of casualties and road safety measures, compulsory seatbelt wearing (Holló et. al., 2010), drunk-driving interventions, speed enforcement, etc. Economic valuation of road safety measures and its methodical analyses established for numerous road injury prevention measures for future application (Elvik et al., 2009).

Fig. 1. EU fatalities and targets 2001-2020

Despite the progress achieved, road safety still causes lot of problems. Accidents are still present and cause serious threat to public health. Recent data show that more than 1.2 million people die worldwide per annum as a consequence of injuries resulting from road accidents. In Europe, an ambitious target of reducing the number of road fatalities by 50% until 2020 was set to the basis of status in 2010 (WHO, 2013).

According to recent estimates, there has been an increase in motorisation level since 1970s, meanwhile the number of fatal road accidents in EU decreased by a half. Among the included accident reducing factors, for example, there is the installation of active and passive safety systems (Schulze, Kossmann, 2010).

Moreover, taking into consideration a fast development of electronic devices in vehicles, and intelligent transportation and communication systems, the hypothesis is that additional efforts are needed in order to be able to evaluate the changing market of road vehicles so as to determine the benefits and drawbacks of automatized road vehicles.

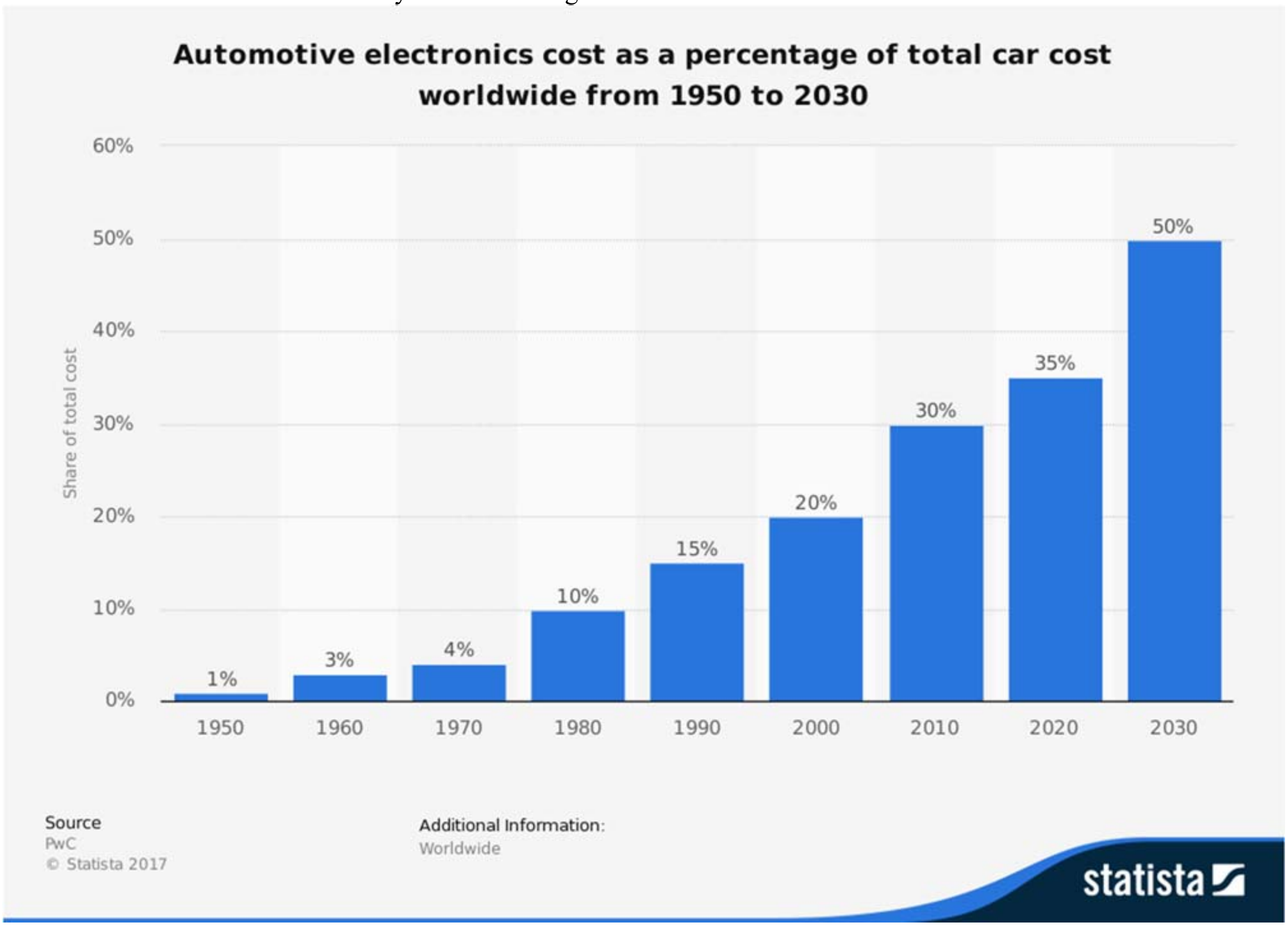

Fig. 2. Automotive electronics cost as a percentage of total car cost

Besides, urgent safety problems in highly populated areas draw more attention to vulnerable road users such as pedestrians and cyclists (Hakkert, Gitelman, 2014; Levulytė et. al., 2016).

2. History of road safety

Road safety research started nearly one hundred years ago. A demand to deal with growing amount of road accidents casualties was recognized. One of the first documented research studies about road accidents was written in 1929. In the last decades, rapid changes have been observed in road transport. Also, the growth (or changes) of population and motorisation, and the expansion of the transport infrastructure were noticed (Farmer, Chambers, 1929; Sipos, 2017).

Furthermore, new trends which influence road safety have occurred, for instance urbanisation and population density, a modal shift from motorised transport to bigger reliance on public transport or an increase in the use of bicycles as well as walking. Fast changes have been noticed in vehicle technologies as well, especially focusing on autonomous vehicles.

Human presence is a factor in more than 90% of road accidents. Importance of an interaction between the road, traffic and vehicle features was highlighted in a the road safety research (Hakkert, Gitelman, 2014).

Before 1960s it was assumed that vehicles on the roads are safe, as they are designed to be safe. Most of accidents that occurred at that time were drivers' errors. The entire legal system and police investigation are still designed to determine the fault of drivers (Hakkert, Gitelman, 2014).

It has become quite obvious that safe vehicle design and the introduction of safety devices (active and passive systems) cannot be avoided. Automatic safety belt systems, although they had been known since the 1980s, were introduced as compolsory standard equipement much later. The airbag was invented in 1951, but was not considered standard equipment until the last deacde of XX. century to become compulsory standard equipment of todays cars (Somers, Hansen, 1984).

Recently, it has become obvious, that improvements in vehicle safety cannot depend on the automotive industry alone, but that the intervention of the government is also needed, governmental and social pressure is essential. This widely occurs in the US, Japan, Europe and Australia. Road safety research has accompanied vehicle safety legislation. As a result, new standards and automotive legislations have been introduced.

Researchers of road safety and some of the decision-makers started to realize in the 1960s and 1970s, that the monocausal approach was not helpful. In most cases, accidents were not a result of a single cause. Multiple effects and their interconnection lead to accidents. A well-known matrix concept was developed as well by William Haddon, in which an accident is described as a short sequence of events before, during and after the crash, wherein countermeasures can be sought. This can be applied to the human, vehicle and road elements involved in the accident. With this new connection, the idea of a driver's fault has lost its significance (Haddon et al., 1964).

It is recommended to analyse accidents in a multidisciplinary way, taking into account the all the circumstances.

Under these circumstances the government is responsible for providing a safe road transport infrastructure, industry's role is to provide safe vehicles while road users are responsible for their own behaviour. The authorities, as part of the state, could apply enforcement to achieve safe transport to regulate the transportation sector. In the future, it would be possible to substitute most of the enforcement with self-enforcing systems, for instance intelligent and smart solutions (Hakkert, Gitelman, 2014).

3. Driver assistance systems

With the current technology and foreseeable future development, the world will massively switch to automatic individual travel mode. The value and impact of such systems on road safety have became one of the most important research issues (Hakkert, Gitelman, 2014).

In recent years, one of the most important goals in the car manufacturing industry has been to offer passengers the highest level of safety, comfort, and efficiency by partially or completely removing duties related to driving from humans and helping them in controlling their car. Studies have shown that active safety systems (adaptive cruise control, electronic stability control, lane keeping), which are already on standard parts of todays' automobiles, can improve road safety (Magdici, Althoff, 2017).

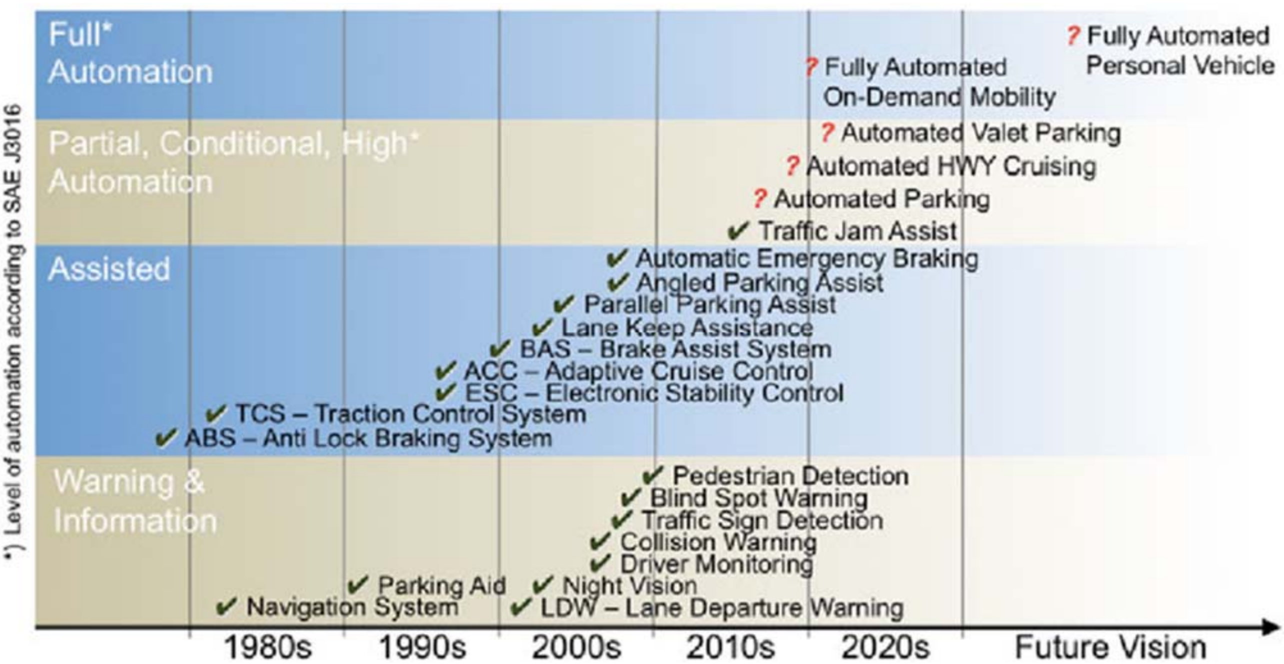

Fig. 3. Timeline for the deployment of advanced driver assistance systems with the vision of fully-automated driving (Beiker, 2016)

The market for advanced driver assistance systems (ADAS) is on the verge of a tipping point, driven largely by requests for improved safety, either via a governmental pressure or the corporate responsibility. Automakers carefully and in a well-planned manner incorporate new technologies and systems that are designed to help drivers avoid accidents. In most cases, they were first introduced in trucks or heavy goods vehicles, and, later, in premium category passenger cars. Only long time after, it became a serial part of commercial passenger cars. Key components that enable ADAS include, among others, cameras, image processors, system processors, ultrasonic sensors, solid-state lidar, high-end lidar, radar sensors, and infrared sensors.

According to a new report from Tractica, ADAS component will increase in the next decade, rising from 218.1 million units shipped in 2016 to 1.2 billion units by 2025. By that time, the market intelligence firm forecasts that the ADAS component market will have reached $89.3 billion in annual revenue (Tractica, 2016). That will overwrite the market and a shift to more automatization will be noticed. In addition to the technological issues that arise from the introduction of such technologies, there are many ethical and legal issues associated with it. The problems of public acceptance, privacy of the data collected, and legal responsibility of the agency operating such a system have not been solved yet, which can be seen as global challenge.

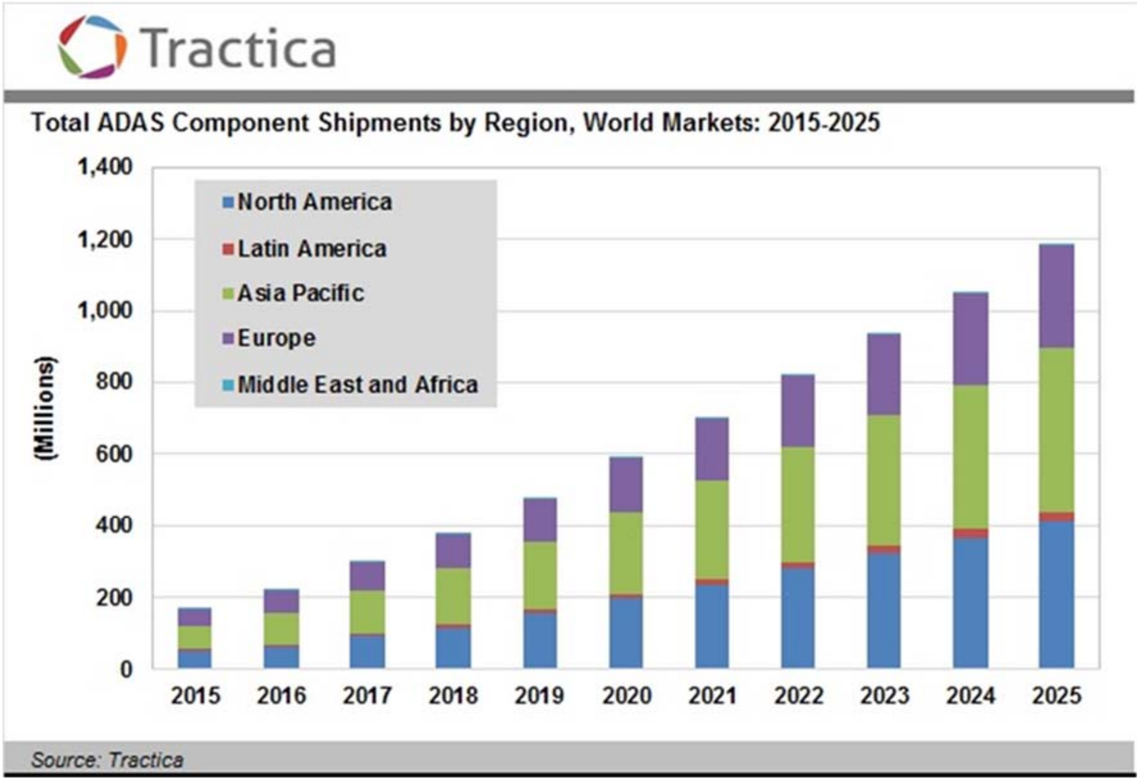

Fig. 4. Total advanced driver assistance systems components shipments prediction

3.1. Autonomous vehicles

Fully autonomous cars without a driver will diminish the risk of accidents, as most of them are the result of a human involvement. Autonomous cars will operate without a human driver, utilising computerised systems to collect information, detect environment and make decisions. Without a human driver, occupants of autonomous cars would become passengers, which could influence the occupancy rate as well and could have effect on modal split.

The concept and practice of autonomous vehicles is not new. It has existed for several decades, an example of it can be a train or metro. It is interesting that the majority of passengers were afraid to use a driverless train or metro. The social acceptance was low, but later people became accustomed to it. However, most of these autonomous shuttles and trains are separated from traffic. Autonomous cars would be used in various situation, and they would interact with other road users, therefore complex interactions and conflicts need to be solved (Hulse et al., 2018).

Driving as a process is very complex. Several cognitive tasks must be performed parallelly, sometimes very quickly in order to ensure the proper vehicular parameters.

Human behaviour is a critical factor in road safety (Holló et. al., 2018). Several forms of road user behaviour have been highlighted recently as increasing the risk of road accidents. Drunk driving, over-speeding, lack of safetybelts and the use of mobile phones while driving. All these elements could influence the reaction time and the time to put a viehicle to a halt (Hulse et al., 2018).

However, to perform the complex task of driving, there must be a mechanism or a computer that supports automatic functions. This need to obey to both the road rules and the social rules (Riaz et al., 2018). The major challenges for such autonomous vehicles are connected with the issue of decision making (Torok, 2017).

4. Conclusion

Autonomous vehicles have a potential to significantly decrease the number of fatal road accidents by eliminating mistakes of human drivers. Autonomous vehicles' driver never become drunk, distracted, or tired. Their performance may also be better than human drivers because of the lack of blind spots.

However, there is a potential risk for autonomous vehicles to cause new and serious accidents, like crashes resulting from cyber attacks. Clearly, autonomous vehicles have an enormous potential for posing risks.

The Americans drive nearly 3 trillion miles every year. The 2.3 million reported injuries in 2013 correspond to a failure rate of 77 reported injuries per 100 million miles. The 32,719 fatalities in 2013 correspond to a failure rate of 1.09 fatalities per 100 million miles (Kalra, Paddock, 2016). For comparison, Google's autonomous vehicle fleet, which currently has 55 vehicles, was test driven approximately 1.3 million miles in autonomous mode and was involved in 11 crashes from 2009 to 2015: Comparing Google's fleet performance with human driven performance one could found that Google's fleet might result in fewer crashes. Unfortunatelly the dataset does not allow to draw the final conclusion. There were not enough autonomously driven miles to make statistically significant comparisons between a man and machine (Kalra, Paddock, 2016)

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公路运输自动化：审查

關鍵詞
道路交通安全
自动驾驶汽车
自动道路车辆
公众接受
风险和劣势

摘要
在本文中，研究了公路运输的自动化。 第一章确定了相关的国际趋势。 在本文中，研究假设是，在自动化道路车辆的情况下，极有可能危及人类生命。 其次，简要介绍了道路安全的历史，特别是车辆设计和系统理论的扫描。 第三章阐述了驾驶员辅助系统的演变，特别强调了自动驾驶汽车。 最后，作者总结说，新的技术解决方案可能会带来新的威胁。