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Professional paper

Connected and autonomous vehicles – road infrastructure challenges

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Abstract – **Nowadays, one of the main concerns regarding road infrastructure development, is the introduction of connected and autonomous vehicles. Therefore, among other things, roads need to be improved in order to accommodate the combination of advanced connectivity systems and automated vehicles. The main goal of this paper is directed towards infrastructure responds to the mentioned challenges expected in the coming years.**

Keywords – **Connected and autonomous vehicles, Road infrastructure challenges, Readiness of road network.**

I. INTRODUCTION

Road infrastructure plays the multifaceted role in meeting the transportation needs in many countries around the world. It is considered as an important component in the processes of economic, environmental and social development, as three basic pillars of sustainability.

In accordance with the relevant literature and professional expertise, the impact of increased vehicle automation and connectivity, especially when it comes to road infrastructure, will result in huge changes of road transport as a whole, and in that manner, on mobility, road safety, traffic management, energy saving, road environment, economy. [1]

This paper is focused on the challenges facing the road authorities and operators which are directed towards different aspects of road infrastructure adaptations to the mentioned technological progress.

As a result of studying the various scientific research papers, reports and documents related to the connected and autonomous vehicles, as well as the major road infrastructure benefits and challenges, the article aims to point out the need of providing a framework for taking measures in overcoming the gaps between the current and future way of using the roads.

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II. AUTOMATED AND AUTONOMOUS DRIVING

The essence of the automated driving definition is focused on the way of driving, i.e., in transfer of the responsibility for various driving activities from the human driver to the automated driving system.[2] The difference between the automated and autonomous driving is based on the degree of involvement the human interaction in the mentioned process. It further leads to the explanation of terms used to describe a type of vehicle such as: automated car (AC), (‘. . . it would follow orders about destination and route, and may only adopt some lane-keeping or car-following guidance’), [3], autonomous vehicle, (AV) - or self-driving vehicles ‘which is capable of fulfilling the operational functions of a traditional vehicle without a human operator), [4], as well as connected vehicles, (CV) and connected and autonomous vehicle, (CAV). In accordance with the fourth mentioned reference, the advanced feature of CV is reflected in its ability to make the connection between the vehicle and its external environs, while CAV is the combination between AV and CV.

How these vehicles work? The way of functioning is the same when the vehicle is driven by the human driver: collecting the information, deciding on the mode of response, and, as a final step, implementation of the decision. This is made possible by advanced technologies related to the vehicle equipment, road infrastructure and the whole driving environment. [5]

The participation of human and cars in different levels of automation is clearly presented in Fig.1,[5]. In addition, the explanation is given below.[6],[7].

‘0 level: NO AUTOMATION – Zero autonomy. The driver performs all driving tasks,

I level: DRIVER ASSISTANCE – Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design,

II level: PARTIAL AUTOMATION – Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times,

III level: CONDITIONAL AUTOMATION – Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.

IV level: HIGH AUTOMATION – The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.

V level: FULL AUTOMATION – The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.,

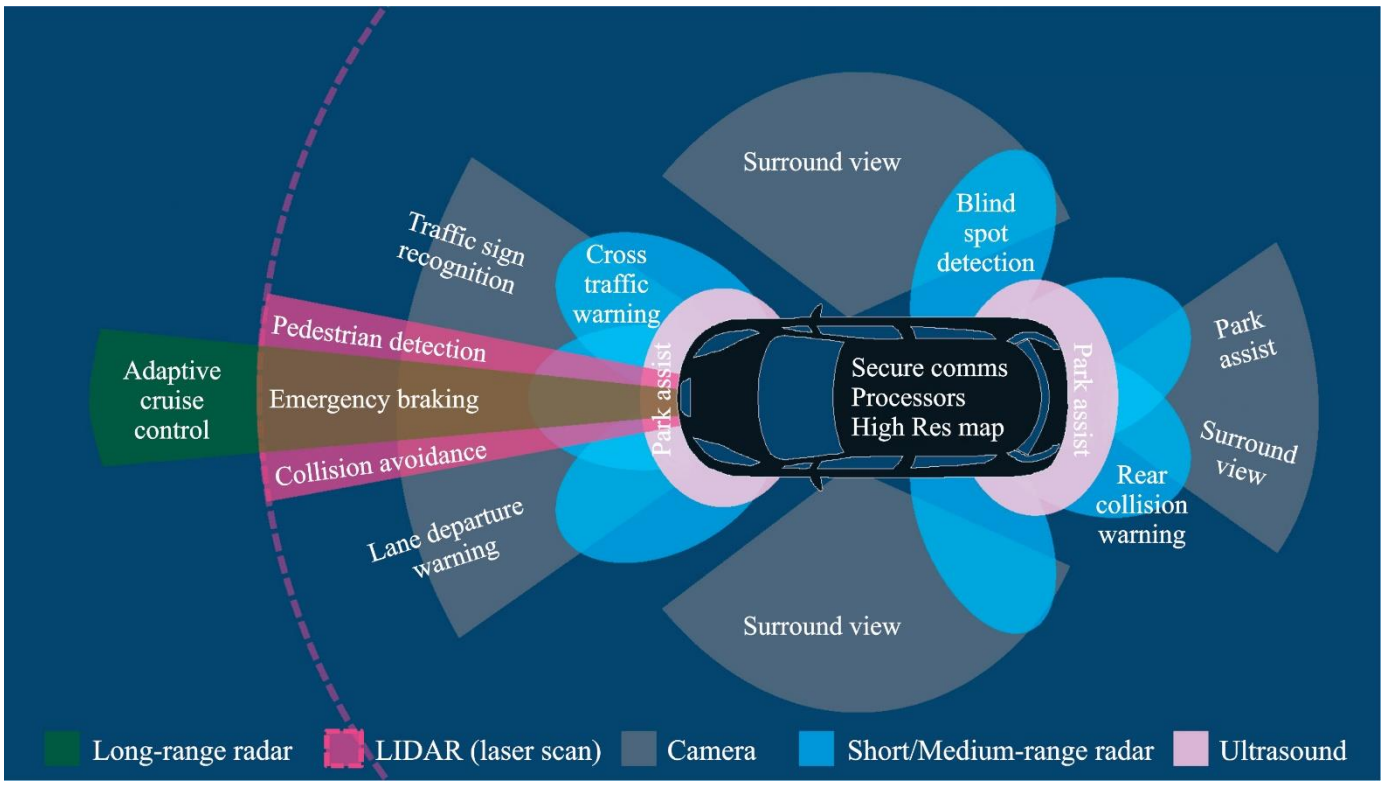

Fig.1.Vehicle technologies that allow adaptation to the driving environment, Adapted from [5]

A. Potentials of automation for improving of road transport

Integration of automation on different mentioned levels is expected to have positive impacts on socio–economic development, (bearing in mind the user impacts, and effects on wider environment as well), through road safety improvement, higher level of personal mobility, changes and increasing in travel demands, better realization of vehicle operations, public health, energy and network efficiency, travel behavior, land use.

Therefore, going through the relevant references, [7],[8], it is expected that new safety technologies, will prevent up to 34% of accidents.

The positive impact is also reflected on shaping and increasing of transport mobility, (more independent mobility, as well as shared mobility, new solutions, better accessibility, social inclusion).

The increase in travel demand, (depending on the type of travel), will range from 2% to 47%. [8]

Automation has great potential for improvements in vehicle operations, starting from assisted driving with partially automated vehicles, up to full automation with the ability to free the human driver of his tasks during driving.

Air pollution resulting from transport is an important public health problem. Current estimations predict decreasing of greenhouse gasses as a result of new car technologies, from 40% to 60% in total. [9].

Energy efficient opportunities in the frame of automated driving is worth mentioning. For example, considerable benefits in fuel consumption are expected using of 90% of autonomous vehicles on suburban roads in USA.[9] On the other side, authors in [10], point to the fact that an increase in energy consumption is also possible, due to the ‘reduced travel cost, higher highway speeds, longer commute distances and inclusion of elderly, disabled and young people as road users.

The road network operation, (through the improvement of traffic efficiency), is also considered as positive effect of automation in road transport, which is reflected on vehicle density and flow rates.

Going through the relevant references can be concluded that automation also have an impact on travel behavior, (number of journeys and vehicle kilometers travelled, transport mode choice, auto ownership), and patterns of land use which impact people’s activities.

B. Challenges in vehicle automation

Apart from the mentioned benefits, it is notable that the vehicle technological development is facing with many challenges in cars and outside the cars, [11] such as:

Implications on road policy;

Road infrastructure demands;

Truck drivers job loss, because the new technology can significantly reduce the need for truck driver employment;

Big security concern, bearing in mind the possibility for cyberattacks and in that way affecting and controlling the vehicle’s operation;

The necessity for changes in current laws or introduction of new ones;

Cost consideration, i.e., high price of these vehicles;

Improving the technology in order to achieve a higher level of vehicle adaptation to different circumstances, such as: type of the road, its surface, weather conditions;

Errors of computer devices which can be a reason for accidents;

Privacy, as an important aspect in using this type of vehicle;

Reducing of driving experience and competencies which could results in difficulties during human driving.

Analysis of the benefits and challenges, leads to the fact, that the automation development in road transport is characterized with considerable uncertainty. Due to the possible conflicts between above mentioned impacts, there is a need for development the strategies and guidelines directed towards optimization in the process of new technologies implementation.

III. ROAD INFRASTRUCTURE RESPONSE

Since the road infrastructure development, is a very complex one, containing several phases and connecting numerous "players", it's obvious there is a need for changes in planning, design, construction and operation, as well as in the roles of critical figures involved in the process.

Connected and automated driving will have impacts on planning related activities. Therefore, there is a need for policy making framework as a base for planning the introduction of new vehicles. The success of this approach depends on the analysis of current and future impacts on road infrastructure sustainability, level of balance between different transport modes and demands of transport users and the necessity for continuous monitoring and evaluation of the obtained results.[12].

Analysis the results of relevant sources leads to the conclusion that the impact of advanced technologies on highway geometric design elements is different.[13]. For example, for human-driven vehicles, the required lengths of different types of sight distance on level sections, upgrades and downgrades, the lateral clearance and curve length, (important for designing the horizontal and vertical curves), as well as the width of lane are substantially greater. However, no impact of vehicle type on curve radius and transition curve length has been identified. Also, there is no need for limitation of the straight sections in horizontal alignment. Due to these reasons, the current procedures for geometric design should be analyzed and, if it is necessary, changed in order to obtain the elements suitable for new vehicles moving.

Besides the mentioned, research indicates that vehicles of the future will have a greater influence on the pavement performance.

When it comes to operation of advanced vehicles, there is a need for facilitation of traffic management through new technologies which will be able to provide real-time information and highly visible traffic signs and road markings. Traffic on cross-roads should be managed by signals and additionally, it is expected that new cars will reduce the demand for parking places.

Road authorities, professionals and planners have a central role in the process of providing the framework for adoption and implementation the policy measures, changing and adaptation of design procedures, maintenance practices and traffic management rules. The main driving force of these stakeholders should be facilitating of this transition period from existing towards fully automated vehicles.

IV. CONCLUSION

The process of road vehicle automation is a part of big progress in technology and everyday living. Therefore, the future of connected and autonomous vehicles is full of promise. On the other side, there is no doubt that the new vehicle technologies produce numerous challenges in transport system development.

Road infrastructure adaptation is one of the crucial prerequisites for implementation of advanced vehicles. The reason for this statement is based on the fact that automation in road transport produces a gap between the way of using the current and future roads. Namely, the mentioned signalizes that the existing infrastructure is not able to meet the needs of increased vehicle automation and connectivity.

Going through the numerous published papers, reports, documents, it is obvious that the changes in different phases of road infrastructure development, (planning, design, construction, maintenance and operation), should be perceived as a bridging tool between the features of existing and future road transport system as a whole.

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