Connected Vehicles Fleet Expanding Problems

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Abstract: The transport systems intellectualization directions analysed in article. The digital technology introduction occurs at all stages of the vehicle life cycle: product development, preparation and production launch, product manufacture, its operation and maintenance. The autonomous vehicles fleet expanding problems are indicated. The intelligent vehicles development and the varying degrees of intellectualization vehicles fleet expansion is accompanied by a number of problems, including those related to the influence of social factors on the transition to fully autonomous vehicles. Consumers are still worried about the consequences of introducing such vehicles, which is related to the security problems. The risk assessment of connected vehicles introduction to the market has been performed. The article concludes with an analysis of connected vehicles ensuring the reliability technical problems.

1 INTRODUCTION

The world economy of the new millennium is characterized by two trends: the rapid development of engineering and technology, which require significant amounts of resources and cause the emergence of negative impact on the environment sources significant number, on the one hand, and on the other, an increase in the number of transition to a «green» and circular economy supporters the initiating the development of program documents and concepts for sustainable development (SD) in all areas of activity. The processes of globalization and urbanization are accompanied by an increase in the need for transportation, which requires solving the issues of transport system stability and security. One of the priority areas, the need for development of which is caused by urbanization negative consequences, the economy real sector development, as well as, often, unjustified harmful human impacts on the environment, indicated in the UNEP «Global Green New Deal», sounds like «Sustainable cities, including planning, transport and green building» (UNEP, 2020).

The UNEP transport strategy, which promoted a paradigm shift towards less road use without compromising mobility, has three areas: «Prevention - Transition - Ensuring environmental cleanliness». To solve this problem, various methods are proposed, the most promising of which is transport systems intellectualization greater process, which, in particular, is reflected in road transport development strategy in Russia AutoNet. Innovations in the field of transport today are very relevant, since transport has a key impact on society, especially in terms of permanent SD. This is reflected in the concept of smart city. At the same time, smart mobility is one of the main issues here, as it provides people with access to places of work and leisure, and is also part of the production and other subsystems in the city's economy.

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2 STATE OF THE PROBLEM: TRANSPORT SYSTEM INTELLECTUALIZATION CONDITIONS AND PROSPECTS

2.1 The Issues of Transport Systems Intellectualization: Smart Mobility

Transition from traditional production to the automation of its processes based on advanced industrial technologies and digitalization is necessary to implement Industry 4.0. Industry 4.0 means a paradigm shift in industrial production towards the use of flexible structures with autonomous, automatically controlled elements. At the same time, enterprise logistics can be optimized using intelligent cyber-physical systems and autonomous vehicles. The creation of autonomous vehicles is one of the key trends in the digital economy, since their introduction will lead to changes in a number of economy and urban economy sectors the related to logistics processes. As a result of digital technologies introduction, vehicle manufacturers are already beginning to engage in direct sales, the traditional business model of the company is being transformed and services such as an online vehicle sales platform and a short-term rental service for special vehicles and vehicles are emerging.

A Deloitte agency review indicates that there are two opposing perspectives on the future of mobility (The Future of…, 2019). Their fundamental differences are mainly related to the question of whether traditional vehicles private ownership current model, driven by humans, is relatively unchanged, sooner or later we will move on to autonomous vehicles, mainly shared. There are also fundamentally different points of view regarding exactly what the path to transformation will be. Proponents of natural evolution idea believe that the development of the business ecosystem of the automotive industry will be consistent and straightforward, and its current assets and fundamental structure will essentially remain unchanged. Opposite point of view adherents - jerking development - predict the onset of a turning point that promises very interesting economic prospects and benefits for society. At the same time, analysts, in view of the competition between the market forces that form the new structure of the automotive industry, identified four different scenarios for its development, which will appear as two key factors influence result: the way of driving (driving with the participation of a person or autonomous driving), the vehicles ownership form (private or joint). According to the results of the analysis, innovations will be unevenly distributed in different countries of the world, whose population experiences different needs for different types of mobility. This means that future transport ecosystem all four forms are likely to exist simultaneously.

The service that provides Real-time Traffic and Travel Information (RTTI) promotes real-time information about the traffic situation and optimal travel routes to increase the mobility of the population. This information (increasingly in conjunction with satellite navigation services) is now being offered, both public and private sources. In the longer term, it is expected that principle of interaction between participants in the movement and infrastructure elements realized systems, including systems are being introduced that provide for the communication and exchange of information between connected vehicles using V2X technology, in particular vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and infrastructure-to-infrastructure (I2I). For V2X technology to become a reality, two areas - automotive and telecommunications - must expand the coverage of the 5G signal and ensure reliable reception. If necessary, the Global Navigation Satellite System (GNSS) capabilities will be used.

2.2 Autonomous Trucks

The automotive industry plays a crucial role in ensuring environmental friendliness and sustainability of the environment, working towards market launch of energy-efficient and environmentally friendly vehicles. At the same time, the transition to autonomous vehicles can be combined with the transition to vehicles with a neutral level of carbon emissions. One way to expand the potential benefits of autonomous vehicles fleet is to use electric vehicles, which are usually more energy efficient.

The most promising area for the use of autonomous vehicles, causing greater confidence among consumers, are cargo transportation and utilities. Autonomous vehicles operate in industries such as farming, inventory management, mining and construction. Uber, Tesla and Mercedes-Benz are experimenting with autonomous driving technology in city buses and semi-trailers.

On the other hand, municipal vehicles and trucking fleets have regular traffic routes and consume large amounts of fuel daily, polluting the cities air pools. It is advisable to organize the transfer of their fleets to more environmentally friendly vehicles. Connected vehicles for urban services are especially relevant, since intelligent on-board systems select the optimal engine operating conditions, which reduces harmful emissions.

So, for garbage trucks that move along a certain route, the automation of the garbage compactor will allow the driver to constantly stay near the console instead of moving between the cab and the rear of the garbage truck. For an automated garbage truck, reversing is much easier than under the control of a human driver. In addition, given that in some areas, reversing heavy vehicles is prohibited or possibly under the control of a traffic controller who helps the driver, an automated truck with a full range of sensors can eliminate these restrictions while improving safety. Since the automation of vehicles is inevitable, it is more likely to use autonomous vehicles in areas involving complex and unsafe activities for humans.

One such area is the mining industry, for which Volvo is testing a truck in the mines. The technology used in autonomous trucks is designed to optimize the logistics of mine routes. So, during a continuous operating cycle, due to traffic planning and maintaining a given speed, congestion disappears, which reduces the time for loading and unloading. Currently, drivers during blasting operations are usually forced to wait for the subsequent ventilation of mine shafts and only then proceed with loading the ore, which in the case of autonomous trucks is an unnecessary measure, i.e. work can begin immediately. Thus, each truck can be used much more efficiently based on transport tasks per shift. As a result, autonomous vehicles become an integral part of the overall production system of mine operations. A more uniform transport cycle and average speed lead to lower fuel consumption and tire wear (Volvo FMX autonomous…, 2020).

Improving the design of connected vehicles, their testing and the transition to alternative energy sources in road transport indicate a growing desire to create more environmentally friendly and intelligent vehicles. In this sense, large enclosed construction sites are optimal for using fully autonomous transport, which allows us to automate the transportation process and reduce the ecological burden on the environment.

2.3 Driver Assistance Systems

Along with the development of fully autonomous vehicles (TS), vehicle producers are working on improving driver assistance systems (ADAS), which use V2x and 5G technologies to communicate with other road users. According to the researchers, a decrease in the role of the human factor in the process of managing large systems will lead to a reduction in the risk of incidents that cause serious consequences in large cities and megacities.

J3016 SAE International's Standard Taxonomy and Definitions for Terms Associated with Automated Driving Systems for Land Vehicles provides a classification system that defines six levels of driving automation from zero to full automation. These are: driver warning systems, combinations of driver warning systems, or automated driving systems (SAE J3016, 2016).

Drivers the world over also wish to be able to decide for themselves when to let a car drive autonomously, and when to control it themselves. More than 63% of respondents in China believe driverless cars will increase road safety, while the figure is 34% in the U.S. and Germany (Survey examines…,2018).

Since the vehicles intellectualization is aimed at ensuring safety on the roads, there are active safety features that are exceptions and are highlighted in this standard, since they operate in critical situations regardless of the driver's desire. Due to the instantaneous nature of the action of active safety systems, their intervention does not alter or exclude the role of the driver in the performance of part or all of the driving functions, and, therefore, are not subject to automation. However, it should be noted that the possibility of avoiding an accident, including the type of active safety systems, can be in vehicles at any level of driving automation.

The traditional driver assistance technology allows to recognize some objects, carry out their basic classification, notify the driver of dangerous situations and, in some cases, slow down or stop the vehicle. This level of technology development does an excellent job of detecting «dead» zones, assisting in changing lanes and warning about the danger of collisions.

2.4 On-board Diagnostic Systems

The vehicles intellectualization, aimed at improving the safety of transport systems, leads to a number of problems associated with the structural and technological solutions complexity. Automotive companies, working in the direction of the development and implementation of autonomous vehicles, predict the emergence of problems associated with their operation period number: both commercial (transportation) and technical (service).

New opportunities and limitations that will have to be encountered when using autonomous vehicles are discussed in articles (Fagnant D.J. and Kockelman K., 2015), (Bonnefon J.-F. et.all, 2016), (Bagloee S.A. et all, 2016). Currently, the conditions for the widespread distribution of autonomous vehicles have not yet been created, since safety issues must be carefully analyzed (Cui J. et. all, 2019). The development of on-board diagnostic systems leads to problems related to the reliability of technical and electronic systems, the organization of their service support, safety (Hacker P., 2017), (Hamada Y. et. all, 2019), (Wang Q et. all, 2018), data privacy and difficulties in applying IT tools and software.

Vehicle producers are interested in predicting the future of autonomous vehicles, the prospects for their introduction into the markets. Studies (Haboucha C.J. 2017), (Bansal P. and Kockelman K.M., 2017) allow us to understand individual motives for choosing when moving to using autonomous vehicles.

Research 1 shows, that 13% of people say they would never use a self-driving car. In contrast however, aversion is twice as high in highly developed economies (UK and USA) as in lesser-developed countries. The question of safety reveals a huge perception gap (Fig.1). Most US drivers feel unsafe that self-driving cars are even on the road. And a huge majority is afraid of riding in an autonomous vehicle (Self-Driving Infographic…, 2019).

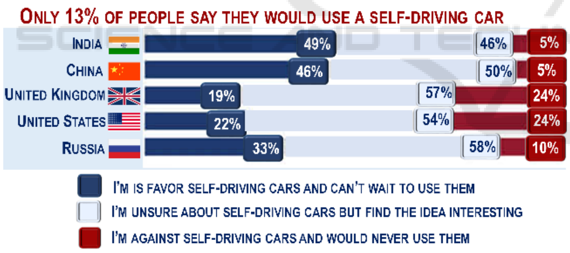

Figure 1: Consumer opinion.

Since autonomous vehicles manufacturers must ensure their trouble-free operation, it is necessary to solve the issues of organizing their service. For vehicles technical condition remote assessment, it is necessary to create a remote database for collecting failure codes and transmitting them to a service center for planning the time of arrival for maintenance and repair and ordering spare parts. At the same time, the issue of choosing the list and installation locations of sensors for automotive components, assemblies and systems timely technical diagnostics that have the greatest impact on safety is being addressed. Currently, numerous studies are devoted to the development of on-board diagnostic systems, for example, in the article (Fong B. et all, 2015) On-board diagnostic system based on predictive information using an intra-vehicle wireless network with additional functions for monitoring driver status, on-board sensors for determine the vehicle condition.

For the entire system of autonomous vehicles operation and service to work in concert, interaction between various subsystems is necessary: road infrastructure, service and logistics systems, the vehicles themselves and other participants in the movement, as well as the production system. For this, a unified information environment and intelligent control systems are created. To a greater extent, the Smart City concept meets this, where all subsystems are covered by intelligent controls. For building confidence in autonomous vehicles requires that people have confidence in cars in terms of cybersecurity and reliability.

3 RESULTS AND DISCUSSION

3.1 The Role of Social Factors in the Transition to Autonomous Vehicles

Assessing possible changes in the transport system during the transition to autonomous vehicles, analysts evaluated, first of all, the opportunities that the economy and society receive:

- Liberation of a person from the routine task of driving vehicles in routine situations, for example, during long-term traffic on highways, in traffic jams, in the urban traffic cycle.

- Reducing accident rate, a significant proportion of which is associated with the so-called "human factor". It is believed that the accident rate reduction can reach 80-90%, since the human factor is the cause of 80% accidents. Perhaps this is too optimistic a forecast, since autopilot robots will make their mistakes typical of robots.

- Growth in vehicle utilization due to fuel economy, the possibility of round-the-clock equipment use, etc.

- Savings in creating road infrastructure. Driver robots, for example, hardly need dividing strips and barriers, so you can use virtual marking - on cards in the autopilot memory, etc.

However, in most cases, positive effects have a downside. Thus, the benefit can lead to losses: the most obvious is the fact that removing the “human factor” from the vehicle control system, we create social tension, reducing the number of people involved in the drivers transportation. In addition, the advantage, designated as «the ability to do some business during the trip", according to doctors, can lead to an increase in ailments due to motion sickness. To avoid this, technical solutions are needed that can be expensive (Scott L.V. et all, 2015).

Academic and independent researchers not only pose numerous complex questions, but also offer possible solutions to future problems.

As shown by the survey's results which conducted in different countries by CISCO (The Network Cisco's…,2020), a significant population part is not yet ready to perceive an autonomous vehicle as a full participant in road traffic. Moreover, the more developed the country, the smaller the number of residents willing to entrust him with their lives and the family lives. This is due to the fact that in these countries they more adequately assess the consequences of failures in vehicles control systems.

Fear of cybercrime around autonomous vehicles is widespread among global motorists—especially in Germany. A full 76% of respondents in Germany believe that personal data can fall into unauthorized hands when using autonomous vehicles (Survey examines…,2018).

According to the HNTB survey, 91% of respondents believe that autonomous vehicles should have someone on board who can take control in an emergency (Autonomous vehicle…, 2020). People fear the vehicle inadequate response to unforeseen situations. Engineers developing autonomous vehicles must solve the problem of matching algorithms that implement the autonomous vehicles actions program with the moral principles if decisions are needed in emergency situations.

Autonomous vehicles on public transport are becoming a promising technology in comparison with existing vehicles. The article (Bosch P.M. et all, 2018) estimates the costs of using autonomous vehicles, as well as their impact on future transportation systems. For one thing, the use of autonomous vehicles increases the purchase price of a vehicle, but on the other hand, it reduces operating costs by lowering insurance premiums, maintenance and fuel costs. In addition, they allow taxi companies to work without drivers, thereby reducing the bulk of their costs. However, given the lack of a driver, customers of such services may exhibit more irresponsible behavior in the vehicle, which leads to faster pollution. At the same time, more frequent cleaning of the cabin and its control are necessary. It has been established that more than half of autonomous fleet operating costs will be the maintenance and management cost (Bosch P.M. et all, 2018).

The introduction of connected vehicles could introduce the practice of using joint rides ("ride sharing"). Sharing connected vehicles will reduce the need for parking spaces. Given the introduction of automated vehicles, sharing services can play an important role in increasing vehicle occupancy and shortening the distance traveled. The results of the study (Lavieri P.S. et all, 2019) show that users are less sensitive to the presence of strangers on a trip to work compared to a trip in their free time. It is noted that travel time added to the trip to serve other passengers can be a more serious obstacle to using shared services compared to the presence of a stranger. The study (Kong P. et all, 2018) indicates that the absence of a person in autonomous vehicles can be solved with the help of a work robot, however, there are many users in public transport, which creates its own difficulties.

Considering the above, it can be concluded that despite the fact that billions are invested in creating an autonomous, connected and environmentally friendly vehicle of the future, consumers are still afraid of introducing these vehicles consequences.

3.2 Possible Risks of Expanding the Market for Connected Vehicles

The vehicles intellectualization, achievements in the autonomous vehicles development lead to a wide range of operational and service risks. It is necessary to assess the risks of bringing connected vehicles to the market. The risk management process usually consists of the stages (Łukasik Z. and Szymanek, A., 2012), (Tuncel G., 2010) of identifying risks, assessing them, choosing a method of mitigation and monitoring and control. Table 1 summarizes the potential risks of expanding the market for connected vehicles. A method for assessing the risk (P) each type occurrence and the risk (consequences C) consequences probability is evaluated on a 5-point scale (table 1).

Table 1: Probability and risk assessment scale.

	1	2	3	4	5
P	Extremely low	Low	Risk is possible	High	Extremely high
C	Without consequences	Small	Significant	Critical	Catastrophic

The risk level (risk level RL) is defined as the product of its probability and the consequences ($RL = P \times C$).

Table 2: Assessment of connected vehicles market expanding potential risks.

Environmental risk					
8	Road networks congestion due to reallocating flows by means of transport	3	3	9	Stimulating the transition of transport to alternative energy sources, improving the quality of travel planning
9	Technogenic accidents risk caused by cyber attacks	2	5	10	Development of protection system against outside, verification of actions in the illogical behavior event correct algorithm
Organizational risk					
10	Risk of disorientation in bad weather	3	3	9	Improving the environment scanning systems
11	The risk of communication with traditional vehicles	4	3	12	Improving gesture and speech recognition technologies
12	Cross country disorientation risk	2	3	6	Improving the algorithms and vehicles design
Legal risk					
13	Risk of legal liability for damage ambiguity	4	4	16	Improvement of legislation

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Since the intelligent module should have a large base for identifying situations and choosing actions, the most voluminous step before launching such vehicles on public roads will be machine learning and algorithm testing.

The main work at the machine learning stage is the collection and purification of data on which the model will learn. If the machine is not sufficiently trained to perceive, for example, persons with different skin colors, glasses and without them, with wide or narrow, brown or gray eyes, this can lead to malfunctions. This will be the risk of erroneous algorithms. The machine has a lot of human-defined options for action in order to cope with the problems that arise, so there is a risk of learning models from data sets that already contain errors. It is necessary to analyze the accumulated statistical information and improve the algorithms.

Connected vehicles vulnerability risk is that there is a great possibility of hacking software and gaining access to driving a vehicle. It is necessary to check the model adequacy with the illogical behavior of the vehicle. The steering system can be checked for the adequacy of the action by tracking information about the deviation from route. The brake system can be checked for an adequate response to traffic signs, compliance with traffic rules. There is also the possibility of an incorrect response to traffic signs in case of poor visibility.

Probability	Level of consequences: 1 Without consequences	2 Insignificant	3 Significant	4 Critical	5 Catastrophic
5 The probability is extremely high	5	10 (7)	15	20	25
4 The probability is high	4	8	12 (6,11)	16 (13)	20
3 Risk is possible	3	6	9 (3,4,5,8,10)	12 (8,12)	15 (1,2)
2 The probability is low	2	4	6	8	10 (9)
1 The probability is extremely low	1	2	3	4	5

Figure 2: Risk matrix.

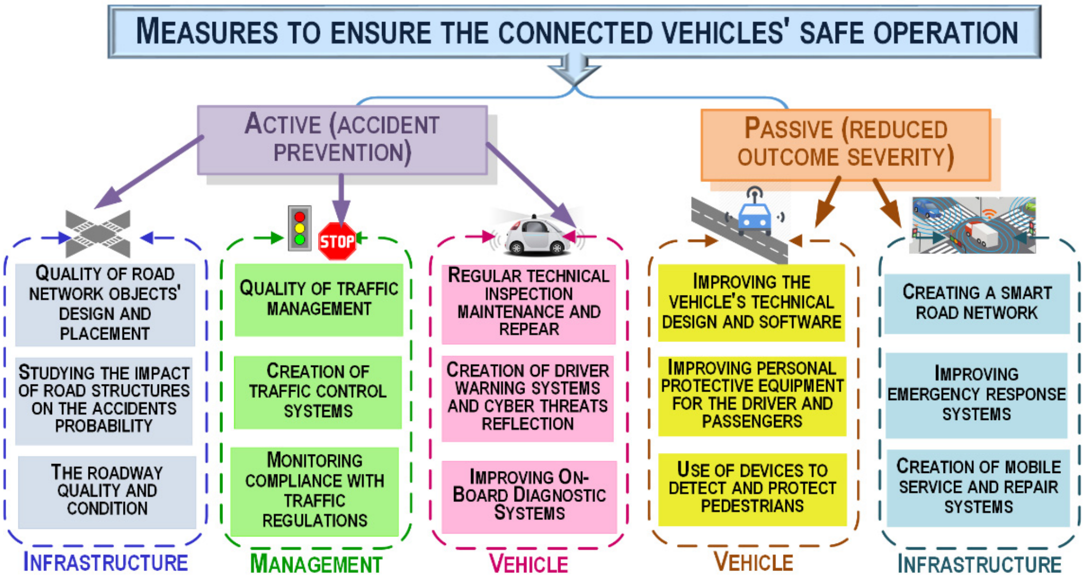

Figure 3: Operational factors affecting the technical condition of connected vehicles.

Introducing connected vehicles consequences will affect the scope of the service infrastructure related to their functioning. There is a reorganizing the service infrastructure high cost risk, including the road, since, first of all, good road surface and clear markings are necessary. The cost is also affected by the need to organize additional sites for vehicle electronic systems diagnosis and maintenance. In this case, retraining of personnel is required to service vehicles.

The risk matrix highlighting the critical area is shown in Figure 2. The risk matrix analysis shows that the most probable risks, which have serious consequences both for the person and for the transport system as a whole, are associated with the risk of erroneous algorithms, vehicles vulnerability and legal liability for damage in a traffic accident ambiguity risk

3.3 Connected Vehicles Reliability

With an increase in the number of connected vehicles, questions of ensuring their reliability will come out. One of the most important and necessary conditions for ensuring the competitiveness of automotive companies in the world market is the improvement of the corporate service system. Dealerships should provide the ability to collect information about the technical condition of connected vehicles, study failure statistics for new vehicle models in order to predict the likelihood of their occurrence.

On-board systems of connected vehicles on each vehicle will signal the need for maintenance and more complex problems, while continuous monitoring of the technical condition is required, which requires the improvement of on-board diagnostic systems. Monitoring the technical condition will prevent premature failures, as well as adjust the modes of vehicle maintenance.

The article (Makarova I. et all, 2018) analyzes ways to increase the operational reliability of trucks by monitoring and diagnosing their technical condition. The possibility of applying the vibration diagnostics method to assess the technical condition and forecasting the remaining service life of the vehicle's clutch is analyzed.

Modern vehicles are equipped with a large number of sensors, and it is obvious that the higher the degree of intelligence, the more sensors it is provided, which affects the reliability of the system. The article (Nitsche C. et all, 2004) proposes an approach that uses artificial neural networks to facilitate the task of on-board diagnostics.

To evaluate the structural and technological reliability of vehicles, calculations and experiments, including computer ones, are performed, however, it is impossible to reproduce all variants of external factors combinations that may arise in actual use. With this in mind, the task of ensuring reliability in real operating conditions should be solved taking into account external influences exerted on the vehicle. In this case, it is necessary to take into account operational factors affecting the technical condition of the connected vehicles. For the connected vehicles' safe operation, the measures on active and passive safety are taken. This applies both to the most connected vehicle and control system, as well as to the infrastructure. (Fig. 3.).

Various combinations of these factors create many emergency situations, nevertheless, it is necessary to single out the main ones and, taking the others as independent factors, determine the patterns and degree of influence on the design of the vehicle.

As vehicles get smarter, technology and infrastructure must evolve in tandem. Automation will increasingly contribute to the rapid reporting of possible vehicle breakdowns, with the ability to reserve a place in the vehicle service for servicing and repairing the vehicle, however, the process of servicing autonomous vehicles will still require human involvement in vehicle maintenance.

4 CONCLUSIONS

The transport sector is currently undergoing significant changes. Connected vehicles are actively entering our lives. The future of connected vehicles largely depends on building consumer confidence in the vehicle. But even though billions are being invested in creating an autonomous, connected and environmentally friendly vehicle of the future, consumers still fear the consequences of introducing these vehicles.

Transport systems intellectualization and automation involves a large number of diverse risks. Based on risk assessment the most likely risks that have serious consequences for both the person and the transport system as a whole are associated with the risk of erroneous algorithms (risk level 15), vehicles vulnerability (risk level 15), and liability for legal damage ambiguity risk (risk level 16). Ideally, the vehicle should predict the actions of the objects surrounding it and, in accordance with this, adjust its behavior on the road, while solving the task. If the vehicle is not adequately trained, this will lead to erroneous actions and endanger road users. There are still many problems to solve in this direction.

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REFERENCES

Autonomous vehicle knowledge is key to acceptance: *HNTB Survey*, 2020 URL: https://www.hntb.com/press_release/autonomous-vehicle-knowledge-is-key-to-acceptance-hntb-su [electronic resource] (accessed January 20, 2020).

Bagloee, S.A., Tavana, M., Asadi, M., Oliver, T. ,2016. Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. *Journal of Modern Transportation*, volume 24, Issue 4, 1 p.p. 284-303.

Bansal, P., Kockelman, K.M., 2017 Forecasting Americans' long-term adoption of connected and autonomous vehicle technologies. *Transportation Research Part A: Policy and Practice,* volume 95, p.p. 49-63.

Bonnefon, J.-F., Shariff, A., Rahwan, I., 2016. The social dilemma of autonomous vehicles. *Science,* volume 352, Issue 6293, p.p. 1573-1576.

Bosch, P. M, Becker, F., Becker, H., Axhausen, K. W., 2018. Cost-based analysis of autonomous mobility services. *Transport Policy*, volume 64, p.p. 76–91.

Cui, J., Sabaliauskaite, G., Liew, L.S., Zhou, F., Zhang, B., 2019. Collaborative Analysis Framework of Safety and Security for Autonomous Vehicles. *IEEE Access*, volume: 7, p.p. 148672-148683.

Fagnant, D.J., Kockelman, K., 2015 Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy and Practice*, volume 77, p.p. 167-181.

Fong, B., Situ, L., Poon, L. C. K., Liu, J.., Mo, R. T., Tsang, K. F., 2015. A prognostics framework for reliability optimization of mass-produced vehicle onboard diagnostics system. *IEEE 4th Global Conference on Consumer Electronics* (GCCE). DOI: 10.1109/GCCE.2015.7398515. pp. 408-409.

Haboucha, C.J., Ishaq, R., Shiftan, Y., 2017. User preferences regarding autonomous vehicles. *Transportation Research Part C: Emerging Technologies,* volume 78, p.p. 37-49.

Hacker, P., 2017. Personal data, exploitative contracts, and algorithmic fairness: autonomous vehicles meet the internet of things. *International Data Privacy Law*, volume 7, Issue 4, p.p. 266–286, URL: https://doi.org/10.1093/idpl/ipx014.

Hamada, Y., Inoue, M., Adachi, N., Ueda, H., Miyashita, Y., Hata,Y., 2019 Intrusion detection system for in-vehicle networks. *SEI Technical Review*, Issue 88, p.p. 76-81.

Kong, P., Cornet, H., Frenkler, F. 2018. Personas and Emotional Design for Public Service Robots: A Case Study with Autonomous Vehicles in Public Transportation. *2018 International Conference on Cyberworlds (CW), IEEE*, pp. 284-287. DOI: 10.1109/CW.2018.00058.

Lavieri, P. S., Bhat, C.R., 2019. Modeling individuals' willingness to share trips with strangers in an autonomous vehicle future. *Transportation Research Part A: Policy and Practice*, volume 124, p.p. 242-261.

Łukasik, Z., Szymanek, A., 2012. Safety And Risk In Road Traffic: Selected Problems. *Transport Problems*, volume 7, Issue 2, pp.83-94.

Makarova, I., Mukhametdinov, E., Mavrin, V., Shubenkova, K., Garipov, R., 2018. Improvement of the Vehicle's Onboard Diagnostic System by Using the Vibro-Diagnostics Method. *International Conference on Diagnostics in Electrical Engineering (Diagnostika).* Conference Paper. Publisher: IEEE. DOI: 10.1109/DIAGNOSTIKA.2018.8526093.

Nitsche, C., Schroedl, S., Weiss, W., 2004 Onboard diagnostics concept for fuel cell vehicles using adaptive modelling. *IEEE Intelligent Vehicles Symposium*, p.p. 127-132.

Standard SAE J3016, 2014. *SAE Intrnational*. URL: https://www.sae.org/binaries/content/assets/cm/content/news/press-releases/pathway-to-autonomy/automated_driving.pdf [electronic resource] (accessed January 20, 2020).

Self-Driving Infographic – All About Self-Driving Cars.2019. *Artchester.net.* URL: https://artchester.net/2019/01/self-driving-infographic/ [electronic resource] (accessed January 30, 2019).

Scott, L. V, Zolfaghari, A., Polak, J., 2015. Autonomous cars: The tension between occupant experience and intersection capacity. *Transportation Research Part C*, volume 52, p.p..1–14.

Survey examines global consumer perceptions of autonomous vehicle safety. 2018. *Autonomus vehicle technology.* URL: https://www.autonomousvehicletech.com/articles/673-survey-examines-global-consumer-perceptions-of-autonomous-vehicle-safety [electronic resource] (accessed January 20, 2020).

The Future of Mobility. A New Deal for Mobility in Belgium. 2019. *Deloitte Belgium.* URL: https://www2.deloitte.com/be/en/pages/strategy-operations/articles/future-of-mobility.html [electronic resource] (accessed January 20, 2020).

The Network Cisco's Technology News Site.2020. Cisco. URL: https://newsroom.cisco.com/press-release-content?type=webcontent&articleId=1184392 [electronic resource] (accessed January 20, 2020).

Volvo FMX autonomous truck tested in boliden mines in Sweden. 2020. *Service trance*. URL: http://str-volvo.ru/node/101 [electronic resource] (accessed January 20, 2020).

Tuncel, G., 2010 How can risks be managed in logistics networks. *Dangerous Materials: Control, Risk Prevention and Crisis Management*, p.p. 93-100.

UNEP, 2020. *Unepcom* URL: http:// www.unepcom.ru/unep/gei.html [electronic resource] (accessed January 20, 2020).

Wang, Q., Qian, Y., Lu, Z., Shoukry, Y., Qu, G., 2018. A delay based plug-in-monitor for Intrusion Detection in Controller Area Network. *Proceedings of the 2018 Asian Hardware Oriented Security and Trust Symposium*, Asian HOST 20189, No 8607178, p.p. 86-91.