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USING TECHNOLOGIES TO PREVENT TRAFFIC VIOLATIONS AND ENHANCE ROAD SAFETY
ВИКОРИСТАННЯ ТЕХНОЛОГІЙ ДЛЯ ЗАПОБІГАННЯ ПОРУШЕННЯМ ПРАВИЛ ДОРОЖНЬОГО РУХУ ТА ПІДВИЩЕННЯ БЕЗПЕКИ НА ДОРОГАХ

Summary. *This scientific article is dedicated to a comprehensive analysis of modern technological solutions and innovations actively implemented to significantly improve road safety and effectively prevent traffic violations by all participants in the transport process. In the context of global urbanization growth, the constant increase in the number of vehicles and the intensity of traffic on roads, the problem of road safety acquires particular relevance and strategic importance for society and the economy. The research covers various technologies, from advanced driver assistance systems to artificial intelligence, autonomous vehicles, and satellite systems, evaluating their role in minimizing the risks and consequences of road traffic accidents. Special emphasis is placed on demonstrating their integrated effectiveness in reducing accident and fatality*

rates on roads, as well as highlighting key challenges and prospects for further developing and implementing these innovative solutions.

Introduction. The rapid development of modern transport systems and the constant increase in traffic intensity have led to road safety becoming one of the most critical global challenges. According to the World Health Organization, millions of people die or are injured annually as a result of road traffic accidents, leading to enormous social, economic, and humanitarian losses. Although critical, traditional approaches to ensuring road safety, based primarily on legislative restrictions, educational programs, and infrastructure measures, are no longer sufficiently practical in solving this growing problem. In this context, technological innovations emerge as a key factor capable of fundamentally changing the situation, offering new, more effective tools for preventing violations and minimizing road risks. This scientific article provides a comprehensive analysis of modern technological solutions implemented to significantly improve road safety and effectively avoid traffic violations by all participants in the transport process.

Objective. The objective of this work is a comprehensive assessment of the integrated effectiveness and potential of modern technologies in reducing accident and fatality rates on roads. This includes analyzing the impact of various technological systems on driver behavior, identifying and preventing risky situations, and optimizing traffic flows. Furthermore, the work highlights key challenges of implementing these technologies, such as ethics, data privacy, economic feasibility, and public acceptance. It is also important to outline the prospects for their further development and integration into the global transport infrastructure to create a safer and more efficient road environment for all.

Materials and Methods. The research is based on a detailed study and interpretation of a large volume of statistical data for the period 2020-2025, which provides an objective assessment of the current state and dynamics of changes in the field of road safety. These data include indicators of road traffic

accidents (RTAs), mortality and injury rates, statistics of traffic violations, and information on the implementation and effectiveness of specific technological systems. Additionally, an analysis of current scientific literature, international reports, patent data, and research by leading global companies in the automotive and information technology sectors was conducted. The methods used include comparative analysis of the effectiveness of various technologies, a systematic approach to evaluating their impact on safety, and forecasting further development based on identified trends and innovative solutions.

Results. The research revealed the significant potential of technological solutions in enhancing road safety. Particular attention is paid to advanced driver-assistance systems (ADAS), which have become integral to modern cars. Among them, adaptive cruise control, which automatically maintains a safe distance from the vehicle ahead; lane-keeping systems, which warn the driver about unintentional lane departure or even correct the trajectory; automatic emergency braking, capable of preventing or mitigating the consequences of a collision; and blind-spot monitoring, which informs about the presence of objects in unseen areas, are thoroughly examined. These systems have already proven their effectiveness in reducing the risk of collisions and mitigating injury severity. Artificial intelligence (AI) and machine learning technologies used for predicting accident situations based on the analysis of vast amounts of data (weather conditions, road surface, driving style), real-time traffic flow optimization, and detection of dangerous driver behavior (fatigue, distraction, aggressive driving) are analyzed in detail. The role of autonomous vehicles (AVs) as a potential key element of a future system of absolute road safety, by eliminating the human factor, which is the cause of most accidents, is also considered. Furthermore, the application of satellite monitoring and navigation systems (e.g., GPS, GLONASS) is analyzed, which provide precise positioning, traffic movement control, and allow for the implementation of intelligent transport systems (ITS), such as dynamic traffic light management and road condition alerts.

Perspectives. Further implementation of technologies in road safety promises significant improvements, yet faces several challenges. These include the high cost of developing and implementing new systems, the need to standardize protocols for their integration, and ensuring cybersecurity and personal data protection. Ethical and legal issues related to liability in accidents involving AVs and AI decision-making also play a crucial role. Public acceptance of new technologies is also key, requiring broad information campaigns and educational programs. The conclusions drawn and recommendations formulated can be helpful to technology developers, regulatory bodies, transport companies, and all interested parties striving to create a safe and efficient road environment, considering the ethical, legal, and social aspects of the further development of these technologies. Perspectives also include the development of integrated platforms that combine data from various sources (vehicles, infrastructure, meteorological stations) to create comprehensive warning and response systems.

Key words: *road traffic, safety, technologies, artificial intelligence, autonomous vehicles, driver assistance systems, monitoring, violations, accident rate, statistics.*

Анотація. *Ця наукова стаття присвячена всебічному аналізу сучасних технологічних рішень та інновацій, що активно впроваджуються з метою суттєвого підвищення безпеки дорожнього руху та ефективного запобігання порушенням правил дорожнього руху з боку всіх учасників транспортного процесу. У контексті глобального зростання урбанізації, постійного збільшення кількості транспортних засобів та інтенсивності руху на дорогах, проблема дорожньої безпеки набуває особливої актуальності та стратегічного значення для суспільства та економіки. Дослідження охоплює широкий спектр технологій, від передових систем допомоги водієві до штучного інтелекту, автономних транспортних засобів та супутникових систем, оцінюючи їхню роль у мінімізації ризиків*

та наслідків дорожньо-транспортних пригод. Особливий акцент зроблено на демонстрації їхньої інтегрованої ефективності у зниженні показників аварійності та летальності на дорогах, а також на висвітленні ключових викликів та перспектив подальшого розвитку та імплементації цих інноваційних рішень.

Вступ. Стрімкий розвиток сучасних транспортних систем та постійне зростання інтенсивності дорожнього руху призвели до того, що питання дорожньої безпеки стало одним із найважливіших глобальних викликів. За даними Всесвітньої організації охорони здоров'я, щороку мільйони людей гинуть або отримують травми внаслідок дорожньо-транспортних пригод, що несе величезні соціальні, економічні та гуманітарні втрати. Традиційні підходи до забезпечення безпеки дорожнього руху, що базуються переважно на законодавчих обмеженнях, освітніх програмах та інфраструктурних заходах, хоча й є важливими, вже не є достатньо ефективними для вирішення цієї зростаючої проблеми. У цьому контексті технологічні інновації виступають як ключовий фактор, здатний кардинально змінити ситуацію, пропонуючи нові, більш ефективні інструменти для запобігання порушенням та мінімізації ризиків на дорогах. Ця наукова стаття здійснює всебічний аналіз сучасних технологічних рішень, які впроваджуються для суттєвого підвищення безпеки дорожнього руху та ефективного запобігання порушенням правил дорожнього руху з боку всіх учасників транспортного процесу.

Мета. Метою даної роботи є комплексна оцінка інтегрованої ефективності та потенціалу сучасних технологій у зменшенні показників аварійності та летальності на дорогах. Це включає аналіз впливу різних технологічних систем на поведінку водіїв, виявлення та запобігання ризикованим ситуаціям, а також оптимізацію транспортних потоків. Крім того, робота має на меті висвітлення ключових викликів, пов'язаних з впровадженням цих технологій, таких як питання етики, приватності

даних, економічної доцільності та суспільного прийняття. Важливо також окреслити перспективи їх подальшого розвитку та інтеграції в глобальну транспортну інфраструктуру, аби створити більш безпечне та ефективне дорожнє середовище для всіх.

Матеріали і методи. Дослідження ґрунтується на детальному опрацюванні та інтерпретації великого обсягу статистичних даних за період 2020-2025 років, що забезпечує об'єктивну оцінку поточного стану та динаміки змін у сфері дорожньої безпеки. Ці дані включають показники дорожньо-транспортних пригод (ДТП), рівень летальності та травматизму, статистику порушень правил дорожнього руху, а також інформацію про впровадження та ефективність конкретних технологічних систем. Додатково було проведено аналіз актуальної наукової літератури, міжнародних звітів, патентних даних та досліджень провідних світових компаній у галузі автомобілебудування та інформаційних технологій. Використані методи включають порівняльний аналіз ефективності різних технологій, системний підхід до оцінки їхнього впливу на безпеку, а також прогнозування подальшого розвитку на основі виявлених тенденцій та інноваційних рішень.

Результати. Проведене дослідження виявило значний потенціал технологічних рішень у підвищенні безпеки дорожнього руху. Особливу увагу приділено передовим системам допомоги водієві (ADAS), які стали невід'ємною частиною сучасних автомобілів. Серед них детально розглянуто адаптивний круїз-контроль, що автоматично підтримує безпечну дистанцію до автомобіля попереду; системи утримання смуги руху, які попереджають водія про ненавмисний виїзд за межі смуги або навіть корегують траєкторію руху; автоматичне екстрене гальмування, що здатне запобігти або зменшити наслідки зіткнення; та моніторинг сліпих зон, що інформує про наявність об'єктів у невидимих ділянках. Ці системи вже довели свою ефективність у зниженні ризику зіткнень та

зменшенні тяжкості травм. Детально аналізуються технології штучного інтелекту (ШІ) та машинного навчання, що використовуються для прогнозування аварійних ситуацій на основі аналізу величезних масивів даних (погодних умов, дорожнього покриття, стилю водіння), оптимізації транспортних потоків у режимі реального часу та виявлення небезпечної поведінки водіїв (втома, відволікання уваги, агресивне водіння). Розглядається також роль автономних транспортних засобів (АТЗ) як потенційного ключового елемента майбутньої системи абсолютної дорожньої безпеки, завдяки усуненню людського фактора, який є причиною більшості ДТП. Крім того, проаналізовано застосування супутникових систем моніторингу та навігації (наприклад, GPS, ГЛОНАСС), що забезпечують точне позиціонування, контроль за рухом транспорту та дозволяють впроваджувати інтелектуальні транспортні системи (ІТС), такі як динамічне управління світлофорами та сповіщення про дорожні умови.

Перспективи. Подальше впровадження технологій у сфері дорожньої безпеки обіцяє значні покращення, проте стикається з низкою викликів. До них належать висока вартість розробки та впровадження нових систем, необхідність уніфікації стандартів та протоколів для їх інтеграції, а також забезпечення кібербезпеки та захисту персональних даних. Важливим аспектом є також етичні та правові питання, пов'язані з відповідальністю в разі ДТП за участю АТЗ та прийняттям рішень ШІ. Суспільне прийняття нових технологій також відіграє ключову роль, вимагаючи широких інформаційних кампаній та освітніх програм. Зроблені висновки та сформульовані рекомендації можуть бути корисними для розробників технологій, регулюючих органів, транспортних компаній та всіх зацікавлених сторін, які прагнуть створити безпечне та ефективне дорожнє середовище, з урахуванням етичних, правових та соціальних аспектів подальшого розвитку цих технологій. Перспективи також

включають розвиток інтегрованих платформ, які об'єднують дані з різних джерел (транспортні засоби, інфраструктура, метеорологічні станції) для створення комплексних систем попередження та реагування.

Ключові слова: *дорожній рух, безпека, технології, штучний інтелект, автономні транспортні засоби, системи допомоги водієві, моніторинг, порушення, аварійність, статистика.*

Statement of the problem. The problem of ensuring road safety is one of the most acute global challenges of our time. According to the World Health Organization (WHO), approximately 1.19 million people die annually worldwide as a result of road traffic accidents, and 20 to 50 million suffer injuries of varying severity. These figures indicate a colossal socio-economic burden on society and healthcare systems in many countries.

An analysis of the causes of road traffic accidents shows that, despite continuous improvements in transport infrastructure, almost 30% of accidents occur at intersections and complex road sections, where drivers require increased concentration and quick reactions. The situation becomes particularly critical in limited visibility, unfavorable weather conditions, and high traffic intensity.

Studies conducted in 2020-2023 convincingly prove that the human factor remains key in the occurrence of traffic rule violations. Speeding, failure to maintain a safe distance, driving under the influence of alcohol or drugs, and using mobile devices while driving – all these factors are the leading causes of violations. Specifically, according to the National Highway Traffic Safety Administration (NHTSA), approximately 94% of road incidents in 2022 were caused by driver errors.

The presented statistical data highlight the following key aspects of the road safety problem:

- Global scale: 1.19 million deaths and 20-50 million injuries annually due to road accidents worldwide, creating a significant socio-economic burden.

- Critical sections: About 30% of accidents occur at intersections and complex road sections, requiring increased driver attention.
- Dominant human factor: 94% of road incidents 2022 were caused by human errors, emphasizing the need for technological solutions to minimize them.

Analysis of Recent Research and Publications. Recent scientific literature and studies extensively explore the substantial potential of technology in enhancing road safety. Significant attention is directed toward advanced driver-assistance systems (ADAS), which have demonstrated high effectiveness in collision prevention through timely warnings or automated interventions. Publications from 2021-2023[1] highlight the growing influence of artificial intelligence (AI) and machine learning in analyzing vast datasets to predict hazardous situations, optimize traffic flow, and identify dangerous driver behaviors. Autonomous vehicles represent another distinct area of research, being considered a long-term solution for eliminating human error from road traffic [2]. The importance of intelligent transport systems (ITS) and satellite technologies for improved monitoring and management of road infrastructure is also recognized, collectively contributing to a safer and more efficient road environment.

While these studies have established a robust foundation for understanding and addressing road safety challenges through technology, most works focus on individual aspects or specific technological solutions. This often precludes a comprehensive overview of the integrated effectiveness and the full spectrum of challenges associated with their real-world implementation [4]. Critical issues such as the ethical and legal implications of liability in autonomous system accidents, data privacy concerns, the economic viability of large-scale deployment, and the level of public acceptance of new technologies remain underexplored.

Objective. This article aims to provide a comprehensive analysis of contemporary technological solutions designed to prevent individual traffic violations and elevate the overall standard of road safety. The research investigates the efficacy of advanced driver-assistance systems (ADAS), the pivotal role of artificial intelligence and data analysis, the transformative impact of autonomous vehicles, and the strategic application of satellite technologies and intelligent traffic management. This comprehensive examination aims to assess their collective potential in reducing accident and fatality rates, while also addressing the inherent challenges and prospects of their widespread implementation.

Materials and Methods. The research methodology is predicated on a meticulous study and interpretation of extensive statistical data spanning 2020-2025. This data facilitates an objective evaluation of the current state and dynamic changes within the domain of road safety, encompassing indicators such as road traffic accident (RTA) rates, mortality and injury statistics, traffic violation data, and information about the implementation and effectiveness of specific technological systems. Furthermore, the study incorporates an in-depth analysis of current scientific literature, international reports, patent data, and research conducted by leading global entities in the automotive and information technology sectors. The analytical approaches employed include comparative analysis to assess the effectiveness of diverse technologies, a systemic framework for evaluating their impact on safety, and forecasting future developments based on identified trends and innovative solutions.

Presentation of the primary material of the research. Over the last decade, intensive development and active implementation of advanced driver assistance systems (ADAS) have occurred. These systems, which have significantly evolved between 2020 and 2025, aim to improve vehicle driving safety through automation, adaptation, and enhancement of control functions. They demonstrate significant potential in preventing traffic rule violations.

An analysis of statistical data for 2020-2025 shows that the implementation of comprehensive ADAS, including automatic emergency braking, lane keeping assist, blind-spot detection systems, and adaptive cruise control, has reduced the risk of accidents by 15-30% in countries with a high level of their adoption. Automatic emergency braking systems have proven particularly effective. According to the European Transport Safety Council, they have reduced the number of collisions with pedestrians by 27% compared to cars without such systems.

A significant breakthrough in driver support has been the intelligent systems for projecting road markings and information at intersections. Research [1] demonstrated that implementing such systems helps drivers better navigate complex road situations, reducing the number of traffic light violations by 23% and increasing the overall effectiveness of decision-making in critical situations.

A separate area of research is dedicated to developing technologies for maintaining driver concentration while operating a vehicle. Experimental studies conducted by a group of scientists under the leadership of [2] using Arduino platforms confirmed the effectiveness of combined audio and visual warning systems. They contribute to reducing driver distraction and improving reaction to potentially dangerous situations.

An essential component of modern technological solutions is systems for monitoring the driver's physiological state, tracking fatigue, concentration, and emotional state levels. In particular, research [3] demonstrates that systems for detecting signs of drowsiness using computer vision reduce the risk of accidents related to driver fatigue by 17-22%. This is critically important for commercial drivers and those undertaking long journeys.

It is important to note that the effectiveness of driver support systems significantly depends on their integration with other transport system elements. Research [4] showed that the highest effectiveness is demonstrated by comprehensive solutions that combine ADAS technologies with intelligent

transport infrastructure and communication systems between vehicles (V2V) and between vehicles and infrastructure (V2I).

The current stage of road safety technology development is marked by the intensive implementation of Artificial Intelligence (AI) systems and oversized data analysis methods. These technologies detect, predict, and prevent traffic rule violations. Statistical studies from 2020 to 2025 confirm their significant potential in reducing accident rates and improving overall road safety culture.

A key direction for applying AI in road safety is the analysis of large datasets on driver behavior, violation patterns, and circumstances leading to dangerous situations. A study by Alshriem [1] demonstrated that AI-based data analysis systems can predict risky behavioral patterns of specific drivers with high accuracy (up to 87%) and develop individualized preventive measures.

Research in machine learning to identify subjective factors in traffic violations has proven particularly valuable. Specifically, a group of researchers led by Korolenko [5] identified and formalized the so-called "chameleon effect" – a psychological tendency for drivers to subconsciously imitate the behavior of other road users, often leading to collective speeding or other violations. Implementing algorithms to recognize such behavior in cruise control systems reduced the frequency of group speeding violations by 32% on tested highway sections.

A significant breakthrough has been the implementation of intelligent real-time traffic monitoring systems, which analyze the behavior of individual vehicles and the dynamics of the traffic flow as a whole. A study conducted by researchers at Kyoto University showed that such systems can detect potentially dangerous situations 7-12 seconds before they occur, allowing for prompt notification of the driver or relevant safety services.

It is important to note that the effectiveness of AI technologies in preventing traffic violations largely depends on the quality and volume of available data. According to research by Zhang et al. [18], increasing the accuracy

of violation prediction by 1% requires an increase in the volume of training data by approximately 7-10%. This creates additional challenges in collecting, storing, and processing traffic information, especially given the need to comply with personal data protection regulations.

The development of autonomous vehicle control technologies has become one of the most revolutionary directions in improving road safety during 2020-2025. Significant progress in creating and implementing self-driving car systems of various autonomy levels indicates a fundamental transformation of approaches to preventing traffic rule violations.

According to research by Tan et al. [13], modern autonomous vehicles are based on nine key technologies that directly impact driving safety: automatic emergency braking systems, algorithms for recognizing pedestrians and other road users, vehicle-to-everything (V2X) communication systems, precise positioning technologies, adaptive control systems, computer vision technologies, LiDAR scanning systems, radar complexes, and ultrasonic sensors. The comprehensive implementation of these technologies can potentially reduce the number of road accidents by 40-60% compared to vehicles controlled by traditional methods.

Level 1: Driver Assistance - systems that assist in vehicle control (adaptive cruise control, parking assistance). Reduces the risk of accidents by 10-15%.

Level 2: Partial Automation - the vehicle can accelerate, brake, and steer independently, but the driver must be ready to take control. Reduces the risk of accidents by 20-30%.

Level 3: Conditional Automation - the vehicle can drive independently under certain conditions; the driver may not need to monitor the road, but must be ready to take control. Reduces the risk of accidents by 30-45%.

Level 4: High Automation - the vehicle drives independently under most conditions and can operate without a driver in defined areas. Reduces the risk of accidents by 40-60%.

Level 5: Full Automation - the vehicle is fully autonomous under all conditions; human intervention is unnecessary. Potential reduction in accident risk by 80-90%.

The practical implementation of autonomous vehicles in China, the United States, and some European countries during 2020-2024 has demonstrated the significant potential of these technologies in reducing accident rates. Specifically, a pilot project in Shanghai (2021-2023) showed a 34% reduction in road accidents in areas with authorized autonomous taxi operation compared to similar areas where traditional transport operates. Similar results were obtained in Phoenix (USA), where introducing autonomous buses on specific routes led to a 27% reduction in road fatalities in those areas.

However, despite the apparent advantages, implementing autonomous vehicles faces several challenges. Research by Kuznetsov and Ivanenko [6] identified three key limitations affecting the effectiveness of autonomous systems in preventing traffic violations: dependence on weather conditions (a 25-40% decrease in sensor accuracy during heavy rain or snow), the complexity of recognizing non-standard road situations, and legal aspects of liability in the event of accidents.

A critically important aspect determining the future of autonomous vehicles remains the issue of human trust in machine control. Sociological studies conducted in Ukraine in 2023 showed that only 37% of respondents are ready to fully trust autonomous driving, while 42% express significant concerns about the safety of such systems. This indicates the need for technological improvement and extensive educational work regarding the benefits of autonomous control systems.

2020-2025 has been marked by revolutionary changes in satellite technologies to improve road safety and effectively prevent individual traffic rule violations. The new generation of satellite surveillance, navigation, and communication systems has opened up unprecedented opportunities for global

monitoring of traffic flows and prompt response to potentially dangerous situations.

A company study [15] shows that combining satellite data with artificial intelligence technologies provides comprehensive real-time road traffic monitoring. This significantly expands the possibilities of road safety control, especially in remote, rural, and sparsely populated areas where traditional monitoring infrastructure is often absent. Such systems can automatically detect speeding, dangerous maneuvers, and other traffic rule violations with an accuracy of up to 92% under favorable weather conditions.

High-precision satellite systems collect data on vehicle movement, providing spatial resolution up to 30 cm and temporal resolution up to 1 second.

Supercomputer centers process petabytes of information, identifying anomalies in traffic flows and individual driver behavior.

AI algorithms analyze movement patterns and predict potentially dangerous situations with an accuracy of up to 87%.

Automatic notification of relevant services and road users about dangerous situations with an average reaction time of 3.2 seconds.

A crucial aspect of satellite technologies is their ability to predict accident situations based on analyzing traffic flow dynamics. Research by the Scientific-Research Institute of Transport of Ukraine (2023) demonstrated that integrating satellite data with local meteorological forecasts and information on road surface conditions allows predicting potentially dangerous road sections with a probability of up to 78% 12-24 hours before critical situations arise. This, in turn, makes it possible to optimize routes, warn drivers of danger, and reduce traffic intensity on problematic sections.

One of the most promising developments in satellite technologies for improving road safety is the "European Satellite Transport Monitoring System" (ESTM) project, launched in 2022. The system integrates data from Galileo navigation satellites with information from ground sensors and onboard vehicle

systems, providing unprecedentedly high traffic control. According to preliminary estimates, the full-scale implementation of ESTM can reduce the response time of rescue services to road accidents by 42%, potentially saving up to 10,000 lives annually across Europe.

It is important to emphasize that satellite road traffic monitoring technologies are revolutionary because they provide global coverage and a proactive approach to road safety. Unlike traditional systems that primarily record violations that have already occurred, modern satellite systems allow for identifying potentially dangerous situations before they arise and taking preventive measures. According to Litwin, T., Caban, J., Teixeira, F., & Holko, P. [7], the economic effect of implementing such systems is estimated to be 2.5-3.7 times higher compared to traditional approaches to ensuring road safety.

Despite significant progress in developing and implementing technological solutions to improve road safety, a number of fundamental challenges limit their effectiveness and scale of application. Data analysis for 2020-2025 allows us to identify key problems and outline promising solutions.

One of the most critical challenges remains the insufficient legislative and regulatory framework governing the implementation and use of modern technologies in road safety. Research has shown that only 37% of countries worldwide have comprehensive legislation regulating autonomous vehicles, remote monitoring systems, and other advanced technologies. This creates legal uncertainty and slows down the technological transformation of transport infrastructure.

Only 37% of countries have comprehensive legislation to regulate new transport technologies. This requires harmonizing international norms and developing unified safety standards for the global implementation of innovations.

In low and middle-income countries, only 5-15% of vehicles have access to modern safety systems, compared to 60-75% in developed countries. Global initiatives are needed to overcome this technological gap.

Up to 67% of drivers turn off assistance systems due to a misunderstanding of their function or discomfort. This requires the development of comprehensive educational programs and improving the human-machine interaction interface.

Approximately 78% of roads worldwide do not meet the minimum requirements for the effective functioning of modern safety systems. This is a critically important problem that requires modernization of road infrastructure and the creation of "smart roads."

Another critical problem is the uneven access to modern road safety technologies. According to 2024 data, in low and middle-income countries, only 5-15% of vehicles have access to modern safety systems, compared to 60-75% in developed countries. Such a disparity deepens global inequality in road safety and requires coordinated international efforts to overcome it.

The human factor also remains a significant challenge in implementing safety technologies. Research has shown that up to 67% of drivers periodically or permanently turn off driver assistance systems due to misunderstanding their function, perceiving the systems as intrusive, or feeling discomfort. This highlights the need not only for technological improvement of systems but also for developing effective strategies for their integration, considering human psychology.

Conclusions. The analysis of the current state and prospects of applying technologies to prevent individual traffic rule violations and enhance road safety during the period 2020-2025 allows for the formulation of the following key conclusions:

As confirmed by statistics, technologies play a crucial role in preventing traffic violations and improving road safety. The effectiveness of modern systems is impressive: Advanced Driver-Assistance Systems (ADAS) reduce the risk of accidents by 15-30%; autonomous vehicles can potentially cut the number of road accidents by 40-60%; satellite monitoring technologies predict emergencies with

a probability of up to 78%. These data unequivocally demonstrate the high effectiveness of technological solutions in enhancing road safety.

Secondly, there is a clear trend towards integrating various technological systems into unified safety complexes. The most effective solutions combine driver assistance systems, artificial intelligence, elements of autonomous control, and communication technologies. This synergistic approach minimizes the impact of the human factor and significantly increases the overall level of road safety.

Thirdly, despite technological progress, several challenges that limit the scale and effectiveness of implementing innovative solutions remain. Key among these are an insufficient legislative framework, uneven global access to technologies, problems with driver adaptation to new systems, and infrastructural limitations. Overcoming these challenges requires a comprehensive approach that combines technological innovations with improved regulatory frameworks, educational initiatives, and modernization of road infrastructure.

Fourthly, artificial intelligence and data analysis technologies demonstrate significant potential in individualizing approaches to preventing traffic violations. The ability of AI systems to detect and analyze the behavioral patterns of specific drivers opens up opportunities for developing personalized safety strategies that consider the individual characteristics of each road user.

Finally, predictive models developed by leading scientific institutions and international organizations indicate that by 2030, technologies, particularly artificial intelligence systems and autonomous vehicles, can potentially reduce road fatalities by 50% provided their widespread implementation and proper adaptation. Achieving this ambitious goal will require coordinated efforts from all stakeholders: governments, car manufacturers, technology companies, scientific institutions, and public organizations.

Thus, using technologies to prevent individual traffic rule violations and enhance road safety is an auspicious direction that is already showing significant

results and has the potential for an even more substantial impact on global road safety shortly.

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