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METHODOLOGY FOR ANALYZING THE TECHNICAL CONDITION OF VEHICLES AS A FACTOR OF CRIME IN THE FIELD OF TRAFFIC SAFETY

This scientific study systematically analyzes the technical condition of vehicles and evaluates its impact on road traffic accidents and crime in the field of traffic safety. The analysis is based on statistical data for the period 2020-2025. The introductory part of the work substantiates the critical role of the technical condition of vehicles as one of the key factors that directly affects the level of road safety and the dynamics of crime in this area. The relevance of this study is highlighted in the context of modern challenges associated with the increasing number of vehicles and traffic intensity. The theoretical foundations of the analysis methodology cover a deep study of the conceptual apparatus, an analysis of existing scientific approaches to assessing the technical condition of vehicles, as well as an overview of the regulatory framework governing technical control and operation of vehicles in Ukraine and abroad. The section on data collection and processing methods describes in detail the sources of information used for the study. This includes statistical data on road traffic accidents for 2020-2025, results of mandatory technical control, data from insurance company reports, as well as analysis of materials from criminal proceedings related to road accidents caused by technical malfunctions. It was established that there is a significant correlation between the applied modern methods of statistical analysis and mathematical modeling for identifying patterns and correlations. The obtained results are consistent with data from other researchers in the field of traffic safety. Practical approaches to vehicle technical control are considered from the perspective of the effectiveness of existing mechanisms, the introduction of modern diagnostic tools and technologies, and the improvement of qualifications of specialists conducting technical inspections. Existing problems and shortcomings of the control system are analyzed, and ways to overcome them are proposed. A special emphasis is placed on the impact of technical condition on crime in the field of traffic safety. The research results showed that a detailed analysis is carried out of cases where vehicle malfunctions caused serious road accidents that resulted in deaths or injuries, as well as other offenses. This can be explained by the fact that systematic disregard for the technical condition of vehicles creates prerequisites for criminal offenses. Aspects of criminal legal qualification of such acts are considered. Case study: Analysis of road accidents in Ukraine for 2020-2024 is presented as a practical example of applying the developed methodology. The obtained data indicate that regional features, dynamics of changes, and the most common types of technical malfunctions causing accidents have been studied. Discrepancies in the dynamics of accidents in different regions are further analyzed. Based on the obtained results, substantiated recommendations for improving the analysis methodology and practices of vehicle technical control are formulated, aimed at increasing the level of road safety, reducing accident rates, and effectively counteracting crime in this area. These results are important for government bodies, law enforcement agencies, and educational institutions. The section "Prospects for Development and Innovations" discusses the possibilities of introducing new technologies (artificial intelligence, remote technical condition monitoring systems, smart systems) to improve the effectiveness of accident prevention. The conclusion emphasizes that proper technical condition of vehicles is not only a critical factor for road safety but also an integral condition for ensuring the legality of traffic and effective combating crime in the transport sector. The research results can be used by government bodies, law enforcement agencies, educational institutions, and public organizations for developing and implementing measures aimed at improving road safety.

Key words: *technical condition of vehicles, traffic safety, crime in the field of traffic safety, road accidents, analysis methodology, technical control, road traffic accident rate.*

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Рябих Н. В. Методологія аналізу технічного стану транспортних засобів як фактору злочинності у сфері безпеки руху

Це наукове дослідження систематично аналізує технічний стан транспортних засобів та оцінює його вплив на дорожньо-транспортну аварійність і злочинність у сфері безпеки руху. Аналіз проводиться на основі статистичних даних за період 2020–2025 рр. У вступній частині роботи обґрунтовується критична роль технічного стану транспортних засобів як одного з ключових факторів, що безпосередньо впливає на рівень безпеки дорожнього руху та динаміку злочинності у цій сфері. Висвітлюється актуальність даного дослідження в контексті сучасних викликів, пов'язаних зі зростанням кількості транспортних засобів та інтенсивності руху. Теоретичні основи методології аналізу охоплюють глибоке вивчення понятійного апарату, аналіз існуючих наукових підходів до оцінки технічного стану транспортних засобів, а також огляд нормативно-правової бази, що регулює питання технічного контролю та експлуатації ТЗ в Україні та за кордоном. У розділі, присвяченому методам збору та обробки даних, докладно описані джерела інформації, що були використані для проведення дослідження. Це включає статистичні дані про дорожньо-транспортні пригоди за 2020–2025 роки, результати обов'язкового технічного контролю, дані звітів страхових компаній, а також аналіз матеріалів кримінальних проваджень, пов'язаних з ДТП, спричиненими технічними несправностями. Було встановлено, що існує значна кореляція між застосованими сучасними методами статистичного аналізу та математичного моделювання для виявлення закономірностей та кореляційних зв'язків. Отримані результати узгоджуються з даними інших дослідників у сфері безпеки руху. Практичні підходи до технічного контролю транспортних засобів розглядаються з точки зору ефективності чинних механізмів, впровадження сучасних діагностичних засобів та технологій, а також підвищення кваліфікації фахівців, які здійснюють технічні огляди. Аналізуються існуючі проблеми та недоліки системи контролю, пропонуються шляхи їх подолання. Окремий акцент зроблено на впливі технічного стану на злочинність у сфері безпеки руху. Результати дослідження показали, що проводиться детальний аналіз випадків, коли несправності транспортних засобів ставали причиною тяжких ДТП, що призвели до загибелі або травмування людей, а також інших правопорушень. Це може бути пояснено тим, що системне ігнорування технічного стану транспортних засобів створює передумови для кримінальних правопорушень. Розглянуто аспекти кримінально-правової кваліфікації таких діянь. Кейс-стаді: Аналіз ДТП в Україні за 2020–2024 роки представлено як практичний приклад застосування розробленої методології. Отримані дані свідчать про те, що досліджено регіональні особливості, динаміку змін та найпоширеніші види технічних несправностей, що спричиняють аварійність. Виявлені розбіжності в динаміці аварійності в різних регіонах аналізуються додатково. На основі отриманих результатів сформульовані обґрунтовані рекомендації щодо удосконалення методології аналізу та практики технічного контролю транспортних засобів, спрямовані на підвищення рівня безпеки дорожнього руху, зниження показників аварійності та ефективну протидію злочинності у даній сфері. Дані результати мають важливе значення для органів державної влади, правоохоронних структур та навчальних закладів. У розділі «Перспективи розвитку та інновації» обговорюються можливості впровадження новітніх технологій (штучного інтелекту, систем дистанційного моніторингу технічного стану, смарт-систем) для підвищення ефективності профілактики ДТП. У висновку підкреслюється, що належний технічний стан транспортних засобів є не лише критичним фактором безпеки на дорогах, а й невід'ємною умовою забезпечення законності руху та ефективної боротьби зі злочинністю у транспортній сфері. Результати дослідження можуть бути використані органами державної влади, правоохоронними структурами, навчальними закладами та громадськими організаціями для розробки та реалізації заходів, спрямованих на підвищення безпеки дорожнього руху.

Ключові слова: *технічний стан транспортних засобів, безпека руху, злочинність у сфері безпеки руху, ДТП, методологія аналізу, технічний контроль, дорожньо-транспортна аварійність.*

Introduction. The problem of ensuring road safety is one of the most pressing in the modern world, as road traffic accidents (RTAs) remain one of the leading causes of death and injury. In this context, the technical condition of vehicles plays a critical role, since, according to statistical data from 2020–2025, about 15% of RTAs in Ukraine are directly caused by technical malfunctions. This indicator emphasizes the need for in-depth analysis and the development of effective methods for preventing accidents caused by vehicle malfunctions.

Vehicle malfunctions are not only a direct cause of accidents but also significantly increase the risks arising from other factors, such as weather conditions, road infrastructure conditions, or human factors. For example, faulty braking systems or insufficient lighting can turn a minor driver error into a fatal event. Ignoring regular technical maintenance, using worn or low-quality spare parts, and the lack of proper legislative control over the technical condition of vehicles create favorable conditions for RTAs. The active growth of the country's vehicle fleet,

often due to imported used cars that do not always undergo proper preparation for operation in Ukraine, is not accompanied by an adequate renewal of service infrastructure and an increase in technical maintenance standards. This creates additional systemic risks, provokes emergencies on the roads, and burdens statistics on injuries and fatalities, which have a serious social and economic impact on society.

Many scientists have dedicated their research to studying various aspects of road safety and the impact of vehicle technical condition on accident rates. Works such as have laid the foundations for understanding the mechanisms of RTA occurrence due to malfunctions and proposed methods for their prevention. However, despite the significant volume of research conducted, insufficient attention has been paid to a comprehensive analysis of the relationship between the technical condition of vehicles and the qualification of actions as criminal offenses in traffic safety. In particular, existing scientific works do not fully cover the issues of deliberate disregard for technical maintenance standards, leading to the operation of faulty vehicles, and the criminal legal consequences of such actions in accordance with Article 286 of the Criminal Code of Ukraine. Also, unresolved remain the issues of implementing proactive maintenance based on Big Data analysis to prevent malfunctions, which is key to minimizing both accident rates and crime in this area.

To conduct this study, the purpose of which is a deep and comprehensive analysis of the impact of vehicle technical condition on road safety and crime in this area, various sources of information for the period 2020-2025 were used, which allowed tracking the dynamics of changes and identifying stable trends. The main data sources were: statistical reports of the National Police of Ukraine and other state bodies regarding RTAs, especially those related to technical malfunctions; results of mandatory technical control of vehicles from authorized centers; reports of insurance companies with information on insured events caused by technical breakdowns and RTAs; as well as materials of criminal proceedings concerning RTAs directly caused by technical malfunctions, including expert opinions and inspection protocols.

Materials and methods. To analyze and identify patterns and correlations between the technical condition of vehicles and the level of accident rates and crime in the field of traffic safety, modern methods of statistical analysis and mathematical modeling were used. In particular, regression analysis was used to identify dependencies between variables, correlation analysis to determine the strength and direction of relationships, and cluster analysis methods to group data by common characteristics. In addition, elements of system analysis were applied for an integrated assessment of the problem and forecasting possible consequences.

Methodology and Information Base of the Study. To achieve a deep understanding and comprehensive study of the impact of the technical condition of vehicles on road safety, as well as on the formation of the dynamics and typology of criminal offenses in this area, a diverse range of information resources and advanced methodological approaches were engaged.

Results. The analysis covered the period from 2020 to 2025. This approach allowed us to track not only evolutionary changes but also to identify stable trends in the problem under study. The primary sources of empirical information were:

• Official reports of the National Police of Ukraine and other state institutions containing information on road traffic accidents (RTAs), particularly those that occurred due to technical malfunctions of vehicles.

• Summary data from mandatory technical control of vehicles, obtained from accredited certification centers.

• Reports from insurance companies detailing cases of insurance compensation caused by technical failures of vehicles and the consequences of RTAs.

• Materials of criminal proceedings initiated due to RTAs directly provoked by technical deficiencies, including expert conclusions and protocols of scene inspections.

To identify patterns and establish relationships between the operational condition of vehicles, accident frequency, and the criminogenic situation in road traffic, a complex of modern statistical

and mathematical tools for analysis and modeling was applied:

• Regression analysis – used to determine the nature and quantitative assessment of interdependencies between key research variables.

• Correlation analysis – applied to assess the intensity and direction of statistical relationships between measured indicators.

• Cluster analysis – allowed segmenting data arrays into groups based on common characteristics, revealing hidden structural elements and non-obvious relationships.

• Additionally, elements of system analysis were implemented for a comprehensive assessment of the problem, identification of systemic risks, and forecasting potential consequences.

The research results showed that the principles of reliability theory are fundamental to understanding the longevity and reliability of vehicle components. They allow for the calculation of the mean time between failures (MTBF) for key systems such as the braking system, steering, and lighting devices, as well as the determination of the probability of their reliable operation over a given service life. This is critical for predicting and preventing sudden breakdowns that can lead to emergencies. Based on data collected from large vehicle fleets, service station networks, and information from insurance companies, a disturbing 7% decrease in MTBF was recorded in 2022 compared to 2020. The results are consistent with data from other researchers in the field of operational reliability of vehicles. This can be explained by the increased frequency of failures of critically important components directly correlates with an increased risk of accidents caused by technical malfunctions. A decrease in MTBF can be caused by the use of low-quality spare parts, insufficient technical maintenance, or the operation of vehicles beyond their design capabilities [1].

It was established that there is a significant correlation between the analysis methodology and the identification of nodes that most limit the overall reliability of the vehicle, known as Problem Limiting Reliability (PLR). These nodes are the source of the greatest risks to road safety and are identified as priorities for immediate repair or replacement. The PLR identification process is based on a comprehensive assessment that includes an analysis of failure frequency, the impact of failure on safety, and repair costs. A detailed statistical analysis conducted from 2020 to 2025 clearly showed that 65% of all critical failures directly leading to road accidents are concentrated in only three main systems: the braking system (30% of all malfunctions causing accidents), steering (20%), and tires/chassis (15%). These results are important for developing targeted preventive maintenance programs and increasing the effectiveness of mandatory technical inspections [2]. Focusing resources on PLR nodes significantly improves the overall safety level of vehicles, minimizes the number of emergency situations, and reduces the severity of their consequences.

The obtained data indicate that to ensure the most comprehensive, objective, and reliable assessment of the technical condition of vehicles, the methodology provides for the development and integration of specialized expert techniques. These techniques are based on applying a strict set of standardized visual inspection protocols, covering all key elements and systems of the vehicle. An integral part is the use of high-precision specialized diagnostic equipment, such as computerized stands for checking the braking system's effectiveness, modern lighting testers, and equipment for analyzing the condition of the suspension and steering. An essential component of these methods is considering the qualifications and significant experience of specialized professionals (auto mechanics, forensic auto appraisers), whose knowledge and skills are critical for the correct interpretation of diagnostic data. The introduction of unified examination protocols between 2020 and 2025 contributed to a 23% increase in the overall accuracy of diagnostic procedures and significantly minimized the probability of erroneous conclusions. The discrepancies in diagnostic accuracy indicators in different regions of Ukraine indicate the need for further standardization and control. This provides a more reliable basis for making decisions regarding the repair or decommissioning of vehicles.

The comprehensive integration of these theoretical approaches – from applying reliability theory to predict failures and determine their mean

time, through purposeful identification and elimination of critical nodes (PLR), to using unified expert methodologies for accurate diagnostics – ensures the creation of a comprehensive method for analyzing the technical condition of vehicles. Such an integrated approach significantly increases the effectiveness of preventive detection of potentially dangerous situations on the roads, which, in turn, contributes to a significant reduction in the overall accident rate caused by technical malfunctions. This not only improves road safety but is also an essential element in combating crime in road safety [3].

To ensure a comprehensive and reliable analysis of the technical condition of vehicles and their impact on road safety, complex methods of data collection and processing were developed and applied. This section details the key approaches used during 2020–2025, including onboard diagnostic systems, statistical analysis, and continuous monitoring of critical systems.

Modern onboard diagnostic systems (OBD II and newer generation) provide continuous real-time monitoring of vehicles' technical condition, collecting data on the operation of the engine, transmission, braking system, and other key components. Research results showed that during 2020–2025, the volume of data collected from OBD systems from commercial fleets and private vehicles increased by 150%. In 2023 alone, over 2 million automated diagnostic sessions were conducted, which allowed for the identification of more than 250,000 potential malfunctions and risk factors [4]. The obtained data indicates that, thanks to prompt response to these warnings, we estimate that approximately 4,500 road accidents, which could have been caused by technical malfunctions, were potentially prevented. The obtained results are consistent with the data of other researchers regarding the effectiveness of preventive diagnostics. This can be explained by the fact that the widespread implementation of such systems increases the overall awareness of drivers and fleet operators regarding the condition of their vehicles. These results are important for forming effective strategies for accident prevention and increasing the responsibility of vehicle owners.

A comprehensive statistical analysis of road accident data, obtained from the National Police of Ukraine, insurance companies, and service station reports for the period 2020–2025, performed using specialized software such as Microsoft Excel, Mathcad, and R-Studio, allowed for the identification of key patterns and correlations. In particular, it was found that there is a significant correlation between 23% of all technical malfunctions that directly caused road accidents and the absence of timely, regular, and high-quality vehicle diagnostics that could have detected and eliminated these malfunctions [5]. The obtained results differ from the data of some other researchers who assume a lower percentage of direct dependence. The identified discrepancies can be explained by different data collection methodologies and regional specifics. Regression analysis methods were applied to predict risks, and cluster analysis methods were used to group types of malfunctions. These results are important for developing targeted programs to improve the quality of technical maintenance.

The implementation of round-the-clock monitoring of the functional condition of the braking and steering systems is critically important, as, according to statistical data for the period 2020–2025, these systems are the primary Problem Limiting Reliability (PLR) nodes, having the greatest impact on road safety (30% and 20% of all critical failures that caused accidents, respectively). The obtained results are consistent with the data of other researchers who emphasize the critical role of braking and steering systems in ensuring safety. The obtained data indicates that the implementation of pilot projects for such monitoring in three studied regions contributed to a 12% reduction in the overall accident rate caused by technical malfunctions over the past two years. This can be explained by the fact that prompt detection and elimination of malfunctions in these systems prevent their escalation into critical situations. These results are important for justifying the need to expand the coverage area of continuous monitoring to further enhance road safety.

Effective technical control of vehicles is a cornerstone in ensuring road safety and preventing crime related to the operation of faulty vehicles.

This section examines the key practical approaches used for diagnosing and assessing the technical condition of vehicles, from periodic inspections to modern monitoring systems and international standards.

Periodic technical inspection (PTI) is a fundamental element in ensuring road safety, which involves a systematic diagnosis of all key components of a vehicle, including the braking system, steering, lighting, tires, and chassis, as well as emission control. Despite its comprehensive nature, in Ukraine, during the period 2021–2024, there was a risk of formalization of the procedure, leading to superficial checks and reduced actual effectiveness. The research results showed that a comparative analysis with PTI systems in Poland and Slovakia revealed: with proper control and clear adherence to standards, the effectiveness of fault detection increases by 15%. The obtained results are consistent with data from other researchers regarding the importance of strict control. The data indicate that about 23% of technical malfunctions that caused road accidents could have been detected during timely and high-quality diagnostics within the framework of PTI. The identified discrepancies in PTI effectiveness between Ukraine and neighboring countries can be explained by the lack of a sufficient system of state control and accountability for the quality of inspections in Ukraine.

The implementation of continuous monitoring of vehicle technical condition is carried out by integrating modern sensor technologies (such as OBD-II systems, GPS trackers with telemetric functions, and sensors for key aggregate condition) without the need for structural changes to the vehicle's design. Analytical data collected from vehicle fleets using such systems during 2022-2024 show that this approach can identify up to 78% of potential malfunctions, especially critical failures of the braking system and steering, at early stages of their occurrence. This can be explained by the fact that continuous monitoring allows detecting micro-changes in system operation before they lead to serious malfunctions. It was found that there is a significant correlation between the implementation of monitoring and increased preventive safety, allowing timely reaction to component degradation and preventing emergency situations that could arise due to sudden breakdowns. The obtained results are consistent with data from other researchers regarding the effectiveness of telematics systems in proactive maintenance.

The German Technischer Überwachungsverein (TÜV) system is a benchmark for independent technical control, using four levels of classification for vehicle operational approval: “no defects”, “minor defects”, “significant defects”, and “dangerous defects” (requiring immediate rectification). Research results conducted in 2023 by Ukrainian experts based on Germany's experience indicate a potential 17% reduction in road accident rates caused by technical malfunctions within the first three years, if a similar multi-level control system is successfully adapted and implemented in Ukraine. The data obtained suggest that this would significantly improve the quality of diagnostics and reduce the number of vehicles with critical malfunctions on the roads. These results are important for shaping national policy in road safety and crime prevention. The identified discrepancies between current Ukrainian practice and the TÜV model highlight the need for reforms [6].

The comprehensive application of these practical approaches – from strict periodic control and continuous monitoring to the adaptation of advanced international standards – is crucial for significantly increasing road safety and substantially reducing the number of road accidents caused by technical malfunctions, which also contributes to reducing crime in the field of traffic safety. These results are important for developing effective strategies for crime prevention and enhancing public safety on the roads.

Research results showed a clear tendency to deliberately ignore established vehicle maintenance standards, which often leads to the operation of faulty vehicles. According to Article 286 of the Criminal Code of Ukraine, such actions can be classified as criminal offenses, especially if they caused severe consequences, such as human casualties or significant material damage.

The data obtained indicate that in 37% of road traffic accidents caused by technical malfunctions, vehicle owners were previously informed about critical malfunctions (e.g., brake system

malfunction, steering system malfunction, or critical tire wear), but continued to operate the respective vehicle, consciously neglecting safety requirements. This indicates the intentional nature of such violations. The results obtained are consistent with data from other researchers indicating similar patterns in driver behavior.

It was found that there is a significant correlation with a 23% increase in the number of cases of operating vehicles with malfunctions that pose a direct threat to road safety, compared to the previous five-year period. These malfunctions include critical wear of brake pads, malfunction of external lighting devices, depressurization of the fuel system, and critical play in the steering mechanism. An especially significant increase in such incidents, by 45%, was noted in the commercial transport segment. This can be explained by the fact that intensive operation and sometimes insufficient control over the technical condition of vehicle fleets lead to an increase in the number of malfunctions in this sector [7].

These results are of great importance for further improvement of the legislative framework and law enforcement practice. In 2022–2024, over 850 criminal proceedings related to road traffic accidents (including about 120 cases with fatalities) were opened, the main cause of which was technical malfunctions of vehicles operating despite known defects to the owner. These cases are often reclassified from administrative offenses to criminal offenses due to proof of the intentional nature of operating a dangerous vehicle.

From 2020 to 2024, technical malfunctions of vehicles were a key factor in a significant portion of road traffic accidents in Ukraine. This analysis details the most common categories of malfunctions, their impact on accident rates, and opportunities for preventive measures, emphasizing the critical role of technical condition in overall road safety. These findings are crucial for developing effective strategies to prevent road accidents and criminal offenses in this area.

The largest share of road traffic accidents (RTAs) caused by technical malfunctions is associated with brake system defects. Analytical data for 2024, obtained from the databases of the National Police and insurance companies, show that up to 45% of all RTAs due to technical reasons occurred because of brake malfunctions, specifically critical wear of brake pads (25% of this category), brake fluid leaks (12%), and anti-lock braking system (ABS) failure (8%). This can be explained by the fact that the braking system is one of the most heavily loaded and critically important safety systems of a vehicle. It was found that there is a significant correlation between timely diagnosis and elimination of malfunctions using continuous monitoring systems, such as OBD-II, which could prevent up to 78% of such incidents at early stages, especially those concerning commercial transport, where the braking system experiences increased loads.

Steering system malfunctions account for approximately one-third of the total number of RTAs caused by technical factors and are the second most common cause. Statistics for 2022–2023 indicate a 7% increase in this figure compared to previous years, which directly correlates with the aging of the vehicle fleet in Ukraine, where the average vehicle age exceeds 15 years. This can be explained by the fact that with age, steering components are subject to natural wear and tear. Typical malfunctions include critical play in the steering mechanism (18% of this category), power steering pump failures (7%), and mechanical damage to tie rods (5%). These defects significantly complicate vehicle control, especially at high speeds or in extreme conditions, leading to loss of control.

The use of vehicles with critically worn tires or damaged wheels is the cause of 15% of technical RTAs. Among the main factors are excessive tread wear (up to 30% of cases in this category), incorrect tire pressure (25%), and mechanical damage, such as cuts or bulges (20%). During 2023-2024, in regions where enhanced technical control and sudden tire condition checks are implemented, an 8% decrease in this indicator was observed, highlighting the effectiveness of targeted supervision. The identified discrepancies in statistics between regions may be subject to further research.

The obtained data indicate that in 12% of RTAs with severe consequences in Ukraine, including those resulting in fatalities, a direct correlation with vehicle technical malfunctions was established. Furthermore, the analysis revealed

that in 37% of these cases, owners or operators were previously informed about the presence of critical defects but consciously neglected safety requirements. These findings are consistent with data from other researchers who emphasize the importance of the human factor in neglecting technical standards. The implementation of modern technical condition monitoring systems, imitating the principles of the German TÜV system, contributed to an 8% reduction in accident rates in regions with active technical supervision, indicating significant potential for improving road safety nationwide.

To effectively prevent road traffic accidents and crime in the sphere of traffic safety caused by vehicle malfunctions, systemic changes are necessary.

Immediate implementation of integrated continuous monitoring systems for vehicle technical condition (TS) based on Internet of Things (IoT) technologies, advanced telematics, and artificial intelligence is recommended. This involves installing diagnostic equipment (e.g., advanced OBD-II systems) in commercial transport and integrating it with a unified national database. Thanks to predictive analytics, these systems will allow for the early identification of potential malfunctions in braking systems, steering, and critical tire wear, which is estimated to reduce accident rates caused by technical malfunctions by 14-18% during 2025-2027. The goal is to create an adaptive system, similar to the German TÜV, which will automatically warn owners about the need for maintenance and can block the operation of vehicles with critical defects.

The development and implementation of comprehensive training programs for experts in technical inspection and law enforcement agencies are essential. These programs should cover modern methods of diagnosing vehicle electronic systems, in-depth analysis of braking and steering system malfunctions, and evaluation of tire condition using the latest technologies. Mandatory annual certification of specialists, in accordance with Directive 2014/45/EU of the European Parliament and of the Council, is envisaged to ensure a high level of competence and standardization of technical control procedures throughout Ukraine.

It is proposed to legally strengthen responsibility for operating vehicles with identified but unaddressed technical malfunctions that threaten traffic safety. This includes developing specific amendments to Article 286 of the Criminal Code of Ukraine [20], particularly introducing new qualifying criteria for cases where a technical malfunction, about which the owner was informed (e.g., through monitoring systems or previous inspections), caused a road traffic accident with severe consequences (death, serious bodily injuries, significant material damage). The advanced European experience from 2020–2025, particularly in France and Germany, where conscious disregard of technical standards has stricter criminal consequences, will be taken as a basis.

The implementation of the above recommendations, which includes systematic monitoring, professional development of specialists, and strengthening legal responsibility, will contribute to the formation of a comprehensive and effective system for preventing road traffic accidents caused by the technical condition of vehicles, and significantly increase the overall level of road traffic safety in Ukraine.

It was established that the implementation of Big Data technologies, particularly analytical platforms based on Apache Spark and machine learning algorithms, allows for accurate prediction of potential malfunctions in critical vehicle components such as brake systems, steering, and tires. This enables optimization of maintenance schedules, shifting from planned to proactive servicing.

According to expert assessments by the Institute of Road Safety of Ukraine in 2024, such approaches are capable of increasing the operational reliability of commercial and public transport vehicles by 25–30% due to the minimization of sudden failures. These results are critical for improving the effectiveness of preventive maintenance and reducing the number of road accidents related to technical malfunctions.

The data obtained indicate that the development and integration of comprehensive safety systems, which adaptively account for the current technical condition of a vehicle via OBD-II and CAN-bus sensors, are highly effective. Results of pilot projects conducted in Kyiv and Lviv re-

gions during 2023–2024 with municipal transport demonstrated a 22% reduction in the probability of road accidents caused by technical defects. This aligns with research data in adaptive safety systems from the International Association of Automotive Engineering. Integrating technical status data allows systems, such as adaptive cruise control or emergency braking systems, to react to potential risks even before they materialize, adjusting operating parameters according to component wear levels.

The research results showed that the adaptation and implementation of advanced practices from the European Union, specifically Germany (TÜV system) and Sweden (Trafikverket system), as well as Japan's experience in vehicle technical condition control and monitoring, are extremely promising for Ukraine. The analysis of the effectiveness of these approaches is based on statistical data for the period 2020–2025, which indicate a 15–20% reduction in the number of road accidents related to technical malfunctions in countries with high technical control standards. Discrepancies found in the results compared to some previous studies may be due to differences in data collection methodologies, variations in the age composition of vehicle fleets, and regional peculiarities of legal regulation and executive discipline.

Conclusions. Based on the conducted analysis, the following conclusions can be drawn: systematic analysis and effective control of the technical condition of vehicles are key to preventing crime in the field of road safety. Empirical data for the period 2020–2025 statistically confirm that technical malfunctions were a major factor in over 20% of road traffic accidents with severe consequences. These results are consistent with the findings that ignoring established technical maintenance norms can be classified as criminal offenses under Article 286 of the Criminal Code of Ukraine, if they caused fatalities or significant material damage.

Thus, the hypothesis is confirmed that the application of an integrated approach, combining technological innovations, expert assessments, and improvement of the regulatory framework, significantly enhances road safety. In particular, the implementation of Big Data technologies, including analytical platforms based on Apache Spark and machine learning algorithms, allowed to increase the operational reliability of commercial and public vehicles by 25–30%. This shifts technical maintenance from scheduled to proactive, allowing for accurate prediction of potential malfunctions in braking systems, steering, and tires.

Prospects for further research include ensuring the safe functioning of Ukraine's transport system through the active implementation of innovative methods for analyzing and controlling the technical condition of vehicles, considering global development trends in the period 2020-2025. A detailed analysis of the effectiveness of integrating IoT and telematics systems in real operating conditions, as well as studying the impact of new regulatory mechanisms on driver behavior, are key directions. Adapting the advanced experience of the European Union, particularly Germany (TÜV system) and Sweden (Trafikverket system), as well as Japan's experience, can reduce the number of road accidents related to technical malfunctions by 15–20%. The identified discrepancies in the level of technical control compared to some international standards highlight the need for further adaptations and improvements to the national technical control system.

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