

are aimed at reducing the number of conflict situations and increasing the overall level of traffic safety at the intersection. The recommended measures will affect the safety of other transport infrastructure facilities in the city, which in turn will help reduce the number of accidents. After the implementation of these measures, the intersection will require a repeat field study.

The field method of studying conflict situations has proven its effectiveness, allowing observation of real conditions and the behavior of traffic participants, which is difficult to predict using modeling. It helps to obtain relevant data on dangerous moments and quickly identify critical points for change. The desk-based method, based on statistical data and modeling, is useful for initial assessment but does not take into account all unpredictable factors, such as changes in driver behavior or weather conditions. Identifying real conflict situations that affect safety is a key advantage of the field method in such analysis.

Further analysis can also use methods such as audiovisual monitoring with video cameras to record situations at intersections, which allow for the analysis of vehicle movement over a certain period, as well as driver surveys, which allow for the collection of qualitative information about their behavior, attitudes toward traffic rules, and impressions of the safety of a particular intersection. This will make it possible to identify patterns of dangerous maneuvers and high-risk areas at intersections, which will significantly increase the effectiveness of measures to improve road safety.

References

1. Аудит безпеки дорожнього руху : підручник / Абрамова Л.С. та ін. Харків: ХНАДУ, 2015. 22с.
2. Chang, L. Traffic conflict technique for safety evaluation. - Elsevier, 2019.
3. Управління дорожнім рухом на регульованих перехрестях у містах: монографія / Форнальчик Є. Ю. та ін. Львів: Видавництво Львівської політехніки, 2018

MODELLING DELAYS AT UNREGULATED URBAN INTERSECTIONS, TAKING INTO ACCOUNT TRAFFIC AND INFRASTRUCTURE

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The relevance of this study is determined by the rapid growth in the number of vehicles, insufficient development of road infrastructure, and increased demands for population mobility. Together, these factors cause congestion in the street and road network (SRN), traffic jams, reduced road safety, and deterioration of the environmental situation in cities. Road accidents present a particular danger, remaining one of the leading causes of human and material losses.

The problem of effective SRN functioning is multifaceted and closely related to the quality of road conditions. These conditions include the geometric characteristics of network elements, the condition of the pavement, traffic organization, the intensity of transport and pedestrian flows, as well as external factors, in particular, weather conditions and environmental features. This is the incompatibility of infrastructure parameters with modern requirements that often causes traffic jams, reduces traffic capacity (TC) and the level of service for road users, while unfavorable external conditions further complicate the situation.

In this context, unregulated intersections require special attention, as they remain vulnerable to external factors due to the lack of active traffic flow management. Their analysis is important both from the point of view of safety and the efficiency of urban transport systems.

In recent years, the global scientific community has paid considerable attention to modeling traffic at unregulated intersections. Research is mainly focused on studying the relationships between road conditions, traffic intensity, and network efficiency. The methodological basis is formed on the basis of simulation tools (VISSIM, SIDRA, HCS) [1,2], heuristic approaches (Logit/Probit models, multidimensional modeling) [3,4], and analysis of spatio-temporal safety parameters (TTC, PET, DR) [5,6,7,8].

A special place is occupied by studies that examine the dependence of delay time on the number of lanes, traffic flow structure, pedestrian load, and infrastructure condition. A significant part of the work also raises the issue of adapting existing

models to mixed traffic conditions, which are characteristic of countries with different transport cultures and infrastructure.

The object of this study is traffic at a typical unregulated straight intersection with four approaches — a configuration that is one of the most common in urban conditions, but at the same time one of the most difficult to organize safe and uninterrupted traffic. Three key factors were selected to evaluate its functioning: the number of lanes on the approaches, traffic intensity, and pedestrian activity. This choice was motivated by the desire to ensure the depth of modeling while focusing on the most significant parameters that directly affect the quality of the intersection's operation. The time of vehicle traffic delay was used as an integral indicator of efficiency, which allows for a quantitative assessment of the intersection's performance, potential time losses, and the impact of interaction between different types of flows (see Fig. 1)

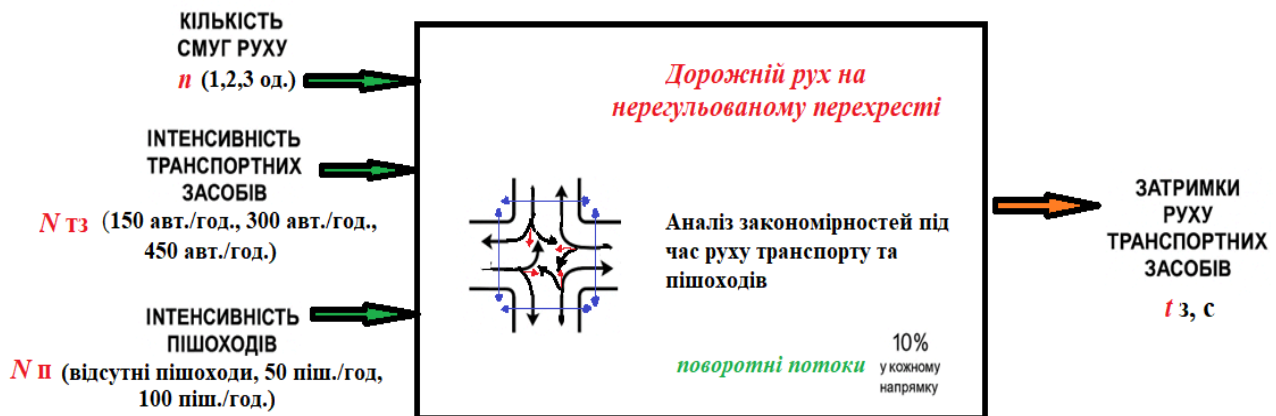


Figure 1 - Model of the research object flows.

To carry out the study, a series of simulation models were created in the PTV VISSIM software environment, which allows complex traffic interaction scenarios to be reproduced under controlled conditions and optimal parameters for improving traffic flow to be determined. Taking into account the peculiarities of unregulated intersections in urban conditions, the model includes a number of restrictions aimed at ensuring its realism and compliance with practical operating conditions. In particular, the number of lanes on each approach is limited to three. This is justified by the fact

that with a larger number of lanes, there is usually a need to introduce traffic light control or other forms of traffic management, which goes beyond the scope of the study of unregulated intersections.

The input parameters for the modeling are defined as follows: number of lanes on the approaches; traffic intensity (150, 300, and 450 vehicles/hour per approach); pedestrian traffic intensity (0, 50, and 100 people/hour). The limit values were selected in accordance with regulatory recommendations, according to which an intensity of more than 500 vehicles/hour per approach or a significant pedestrian flow requires the introduction of regulation to ensure an acceptable level of safety and reduce delays. Particular attention in the model is paid to turning flows. Their share is set at 10% (for each direction — right and left), which corresponds to typical traffic conditions within urban areas, where straight movement prevails. If this share exceeds 20–30%, the model may need to be adjusted due to changes in the conflict structure and priorities at the intersection. The distribution of traffic directions by lanes is implemented in accordance with typical traffic management schemes at unregulated intersections: 1 lane — universal direction (straight, right, left); 2 lanes — straight movement from both lanes, right — from the right lane, left — from the left lane; 3 lanes — straight movement from all lanes, turns — from the outer lanes of the corresponding direction.

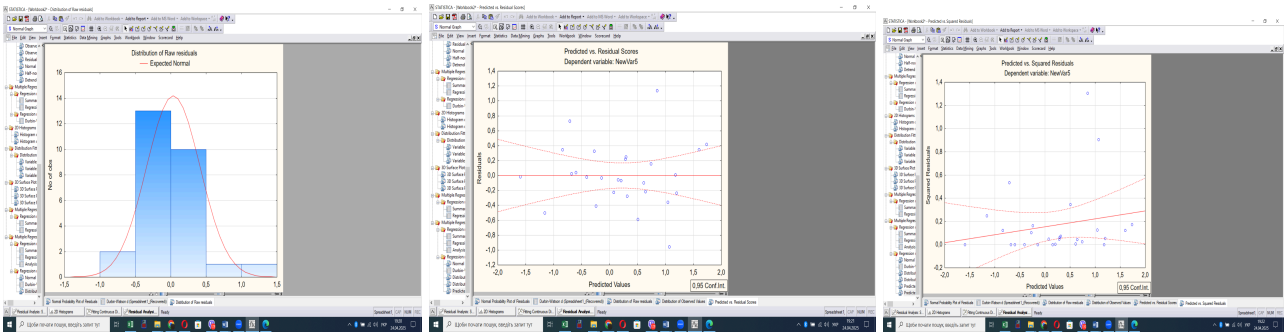
This approach brings the model closer to real operating conditions and allows for an objective assessment of the impact of road parameters on the efficiency of intersection operation, in particular on vehicle traffic delays.

In order to ensure a balance between the depth of analysis and the scope of modeling, it was decided within the framework of this study to reduce the number of variation scenarios formed on the basis of an expanded matrix of combinations of road condition parameters. In the initial version, the matrix contained a complete set of scenarios, including combinations of the number of lanes on the main and secondary roads (1×1 , 2×1 , 2×2 , 3×2 , 3×3), traffic intensity levels (150, 300, 450 vehicles/hour) and pedestrian traffic (0, 50, 100 people/hour). However, taking into account the specifics of the research object and the practical feasibility of the analysis, scenarios with configurations 1×1 and 3×3 were excluded from further consideration, each of

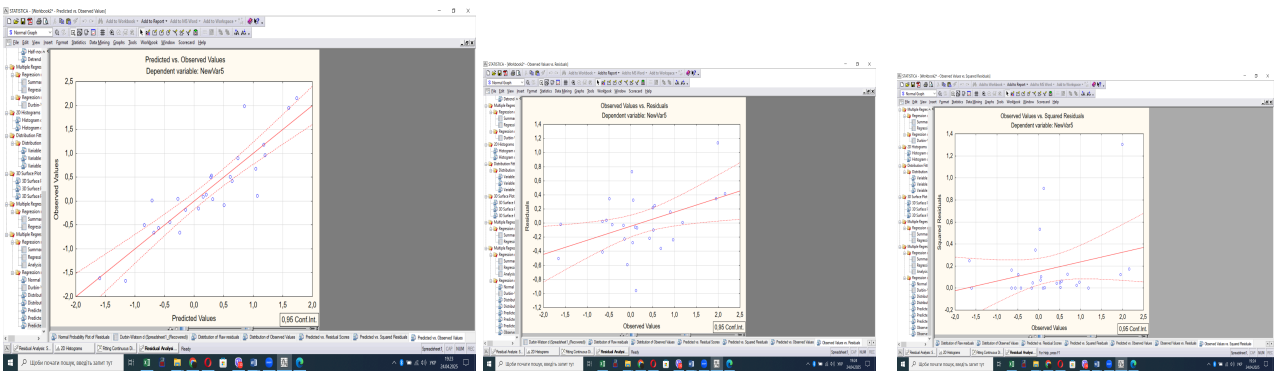
which has its own valid reasons for exclusion. First, a 1×1 intersection (one lane on each approach) represents the simplest form of an unregulated junction with a minimum level of conflict and limited PS. In such conditions, traffic interaction is predictable and linear, which limits the possibility of identifying new patterns. Therefore, modeling such options does not add significant scientific novelty and duplicates basic situations that are intuitively obvious or already well described in the literature. Second, the 3×3 configuration (three lanes on each approach) significantly exceeds the typical scale characteristic of unregulated intersections. This structure approaches a level of complexity at which, according to design standards and practice, traffic lights or other enforcement measures are usually introduced. In addition, with this number of lanes, the nature of conflict points changes, and straight flows are given dominant priority, making comparison with smaller configurations impossible.

Thus, the final set of scenarios for modeling covers combinations of 2×1 , 2×2 , and 3×2 , which allows for the necessary variability of the study and ensures analytical depth without overloading the modeling process. A total of 27 scenarios were selected for analysis, representing the most characteristic and typical situations for unregulated intersections in an urban environment.

As a result of simulation modeling in the PTV VISSIM environment, an array of data was obtained that reflects the values of vehicle traffic delays under various road conditions. The collected data became the basis for conducting a correlation-regression analysis, within which functional dependencies between the parameters of the transport environment and the magnitude of delays were established. Among the types of regression models analyzed in the STATISTICA program, the power model proved to be the most adequate in terms of accuracy and statistical significance, and was retained for further use in the study (see Fig. 2)



Balance charts



Balance Assumption Check Charts

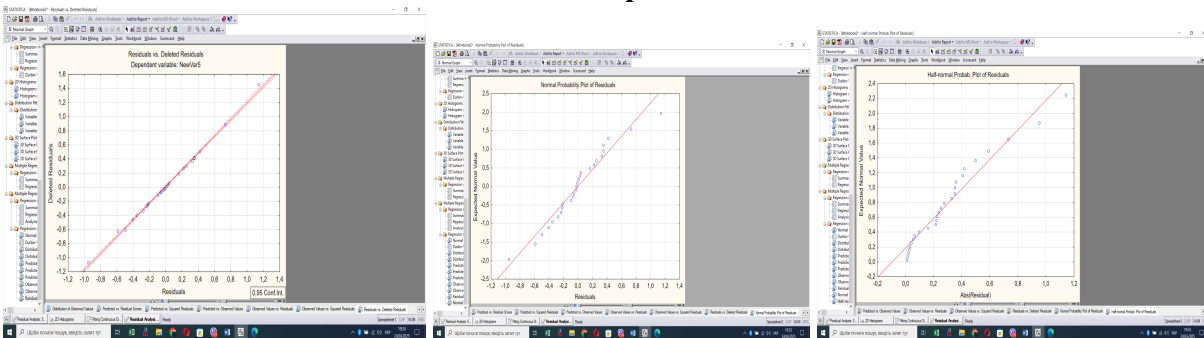


Figure 3 - Comprehensive statistical assessment of the adequacy and quality of the regression model of delays with three parameters

The constructed dependence allows predicting the level of traffic delays at an unregulated intersection, taking into account three key factors: the number of lanes on the approaches, the intensity of traffic accidents, and the intensity of pedestrian traffic. The analytical form of the model is as follows

$$t_{T3} = 0,0238 \cdot n^{-1,95} \cdot N_{T3}^{1,32} \cdot N_{\Pi}^{0,192} \quad (1)$$

Based on the modeling results, it was found that three key factors — the number of lanes, traffic intensity, and pedestrian traffic intensity — significantly affect the level

of delays at uncontrolled intersections. Number of lanes: increasing the number of lanes leads to a noticeable reduction in delays. The lowest values are observed in configurations with a total of 5–7 lanes. At the same time, excessive expansion (more than 12 lanes) is impractical from the point of view of urban restrictions, safety, and economic feasibility. Vehicle intensity: the impact of this parameter is almost linear — with an increase from 1,000 to 4,000 vehicles/hour, delays increase from 28.13 to 175.35 seconds. This confirms the feasibility of the design restriction of traffic intensity to 2,000 vehicles/hour per approach, unless special traffic management measures are provided. Pedestrian flow: with an increase in its intensity from 50 to 1200 people/hour, delays increase from 19.94 to 36.71 seconds, which emphasizes the need to design effective pedestrian infrastructure to minimize conflicts.

The results are visualized in the form of a bubble chart (see Fig. 4), where the intensity of vehicles and pedestrians is shown on the axes, and delays are shown by the size of the markers.

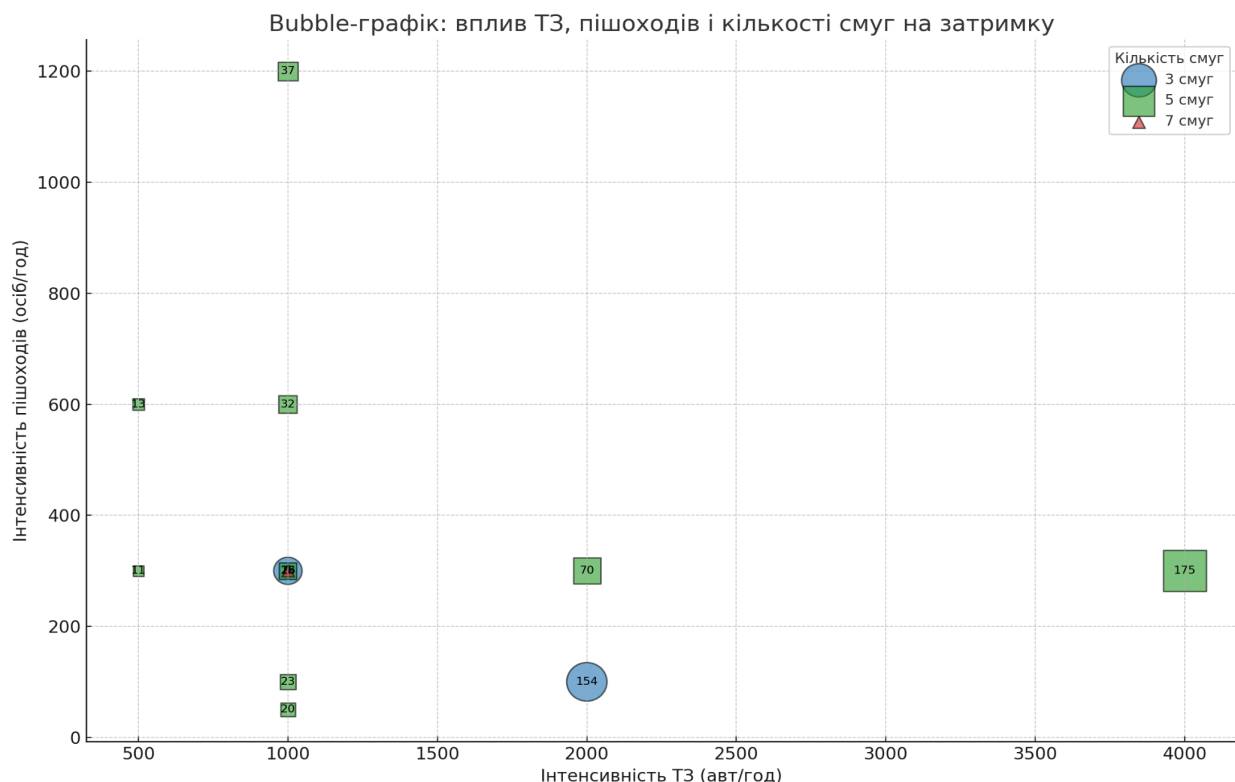


Figure 4. Bubble chart for analyzing the resulting model

The analysis shows that the main factor contributing to delays is the intensity of vehicle traffic, especially when there are not enough lanes. Pedestrian traffic also has a significant impact, but it is less critical than vehicle traffic. Therefore, effective design of unregulated intersections should be based on rational geometry, controlled traffic intensities, and adaptive traffic management. The data obtained can serve as a basis for empirical justification of modern design solutions in the context of increasing urbanization.

The results of such modeling can be further used both for scientific purposes — to develop new approaches to the analysis of transport systems — and in the practice of urban planning and road infrastructure management. This opens up opportunities to improve the efficiency of transport services, minimize delays, and improve traffic conditions within the urban SRN. Thus, the study fits into the general trend in modern science toward multifactorial analysis of road traffic efficiency. Its result is the formation of substantiated conclusions regarding the impact of road conditions on vehicle delay times at unregulated intersections, which is a significant contribution to both the development of transport modeling and urban planning practice.

References

1. Ranjitkar P, Shahin A, Shirwali F. Evaluating Operational Performance of Intersections Using SIDRA. *Open Transp J*, 2014; 8:.. <http://dx.doi.org/10.2174/1874447801408010050>
2. Fatlawy Huda Majeed. Evaluation of traffic operation at selected zone of roadway network in Kerbala City : master's thesis / Huda Majeed Fatlawy ; supervisor: Prof. Dr. Hussein Ali Ewad, Dr. Raid R. A. Almuhanha ; Ministry of Higher Education and Scientific Research, University of Kerbala, College of Engineering, Department of Civil Engineering. Kerbala, 2019. 153 p.
3. Suprabeet Datta, Siddhartha Rokade, Sarvesh P.S. Rajput. User-satisfaction based operational evaluation for uncontrolled intersections under mixed traffic, *Alexandria Engineering Journal*, Volume 60, Issue 1, 2021, Pages 1085-1103. ISSN 1110-0168, <https://doi.org/10.1016/j.aej.2020.10.032>
4. Ashalatha, R., Chandra, S. Critical gap through clearing behavior of drivers at unsignalised intersections. *KSCE J Civ Eng* 15, 1427–1434 (2011). <https://doi.org/10.1007/s12205-011-1392-5>
5. Singh, D., Das, P., Parvez, N. M. Surrogate Safety Evaluation at Uncontrolled Intersection in Non-Lane Base Traffic Conditions. *European Transport*.

2023. Issue 93, Paper № 11. ISSN 1825-3997. DOI: <https://doi.org/10.48295/ET.2023.93.11>.

6. Kumar, V., Hassan, T., Raj, U., Gaurav, A., Kumar, N. Evaluation of Uncontrolled Intersection Performance Based on Microscopic Simulation // International Research Journal of Education and Technology. – ISSN 2581-7795. URL: <https://www.irjweb.com/final%208th%20sem%20updated%20journal.pdf> (дата звернення 27.04.2025)

7. Dungar Singh, Pritikana Das, Indrajit Ghosh, Conflict-Based safety evaluations at unsignalized intersections using surrogate safety measures, Heliyon, Volume 10, Issue 5, 2024. e27665. ISSN 2405-8440. <https://doi.org/10.1016/j.heliyon.2024.e27665>.

8. Mohammad, A. A., Al Nawaiseh, H. M., Alhajyaseen, W. K., Dias, C., & Mehran, B. (2023). Lane-based analysis of the saturation flow rate considering traffic composition. *Transportation Planning and Technology*, 46(5), 653–671. <https://doi.org/10.1080/03081060.2023.2214144>

HOW SUPPLY CHAINS AND TRANSPORT LOGISTICS AFFECT MILITARY OPERATIONS

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In modern warfare, victory is not solely determined on the battlefield but is profoundly influenced by the efficiency of supply chains and transport logistics. These elements form the circulatory system of any military force, directly impacting its operational reach, sustainability, and combat effectiveness.

A robust logistics network ensures the timely delivery of critical resources: ammunition, fuel, spare parts, and food. The inability to sustain these flows can halt an advance faster than enemy action. For instance, the success of rapid maneuvers and blitzkrieg tactics is entirely dependent on a seamless fuel and ammunition supply. Conversely, logistical failures have historically led to catastrophic defeats, crippling armies not by combat losses, but by attrition and starvation.

Transport logistics dictate the tempo of operations. Control over key infrastructure—ports, railways, and highways—becomes a strategic objective. Modern conflicts highlight the vulnerability of supply lines to disruption, making them primary targets for long-range strikes. Furthermore, the complexity of coordinating multi-modal