Journal of civil engineering and transport **transEngin**

2026, Volume **8** Number **1** **ISSN 2658-1698, e-ISSN 2658-2120**

DOI: 10.24136/tren.2026.002

RESEARCH AND ANALYSIS OF KEY FACTORS INFLUENCING THE EFFECTIVENESS AND SAFETY OF NON-STANDARD ROAD TRANSPORT

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Reviewed positively: 14.12.2025

Information about quoting an article:
Łoś W., Szkoda M. (2026). Research and analysis of key factors influencing the effectiveness and safety of non-standard road transport. *Journal of civil engineering and transport*. 8(1), 23-37, ISSN 2658-1698, e-ISSN 2658-2120, DOI: 10.24136/tren.2026.002

Abstract – The article examines key factors influencing the efficiency and safety of non-standard (oversize) road transport in Poland. Due to the growing demand for transporting large and heavy cargo, this sector has become a crucial yet highly demanding element of logistics. The study identifies major organizational, infrastructural, and administrative barriers and proposes directions for systemic improvement. The research combined a literature review, cooperation with Schwerlast A.L., and a survey among 34 transport companies and 52 professionals representing various organizational levels. Both quantitative and qualitative analyses revealed that systemic inefficiencies significantly limit operational performance. The paper proposes developing an integrated digital platform for permit submission and monitoring, modelled on the German VEMAGS and Lithuanian automated routing systems. Such a system would unify administrative standards, automate data exchange, and significantly shorten decision times. Respondents also emphasized the need for dialogue between the transport industry and government authorities, modernization of bridges and infrastructure, and the creation of additional technical bays and parking areas. The study concludes that improving the efficiency of oversize transport in Poland requires simultaneous reforms in infrastructure, administration, and legislation. The introduction of nationwide digitized procedures and better coordination between institutions could enhance efficiency, safety, and competitiveness in this crucial logistics sector.

Key words – non-standard road transport, oversize cargo, infrastructure barriers, transport safety

JEL Classification – L62, L69, L90, L92, R40

INTRODUCTION

With the rapid development of industrial processes and the increase in demand for the transportation of large and heavy infrastructure components, the importance of non-standard transportation is steadily increasing. The organization of this type of transportation is a complex process, integrating different types of logistical activities. The loads carried then exceed certain standards in terms of weight, dimensions, and axle loads of the vehicle on the roadway. In addition, each oversized freight shipment requires an individual approach due to the characteristics of the cargo being transported. These activities require specialized equipment and a precise interpretation of the detailed laws governing the organization of non-standard transportation [15, 18].

According to information obtained through cooperation with SCHWERLAST A.L. [11], despite the significant development of technology and the availability of specialized equipment to safely move oversized cargo, the implementation of this type of operation still faces a number of barriers, related to both infrastructure constraints and the complexity of administrative procedures. This paper attempts to identify key organizational and systemic barriers related to the organization of non-standard transportation in Poland, particularly in the context of the functioning of public administration and the state of road infrastructure. The aim of the study

was to identify areas for improvement in procedures and communication with the administration, as well as opportunities to utilize available digital tools.

The results of a survey of 34 companies providing non-standard transportation services in domestic and international traffic were used as research material. Among the 52 respondents, who are specialists in the industry in question, there are CEOs, general directors, and managers in charge of logistics operations, as well as technologists, drivers, and pilots handling non-standard cargo services. The use of a structured questionnaire, including both short closed-ended questions and extended open-ended questions, allowed for obtaining reliable quantitative and qualitative data on the implementation of non-standard transportation in practical conditions. The scope of the survey included different levels of the companies' organizational structure, which made it possible to comprehensively identify the real problems and barriers occurring in this branch of transportation, as well as to formulate conclusions containing the expectations of industry representatives with regard to necessary system changes. In addition, an analysis of the available scientific and industry literature was carried out, and the necessary operational information was obtained through cooperation with the Schwerlast Aleksandra Ledwig company.

The main part of the article is devoted to the analysis of the administrative processes accompanying the organization of non-standard shipments and the assessment of the quality of cooperation between carriers and public institutions. The aforementioned aspects are now key considerations affecting the efficiency and timeliness of this type of transportation. The conclusions obtained in the course of the research are intended to deepen the understanding of the systemic barriers occurring in the area of non-standard transit. They can provide a substantive basis for further analysis and discussion of the directions for optimizing organizational, infrastructural, as well as administrative solutions in this sector.

a) **b**)



Fig. 1. Examples of non-standard road transport a) the submarine ORP Sokół has dimensions of 45.00 × 8.00 × 5.00 m and a weight of 380 t [9]; **b) the vehicle composed of two tractors and two semitrailers between the tractors** [10]

1. LITERATURE STUDY IN THE FIELD OF OVERSIZED LOADS ROAD TRANSPORTATION

1.1 LEGAL CONSIDERATIONS FOR NON-STANDARD CARGO TRANSPORTATION PERMITS

In order to transport cargo classified as non-standard, the carrier is required to obtain the relevant permits in each country through which the planned route passes. These documents should contain detailed information about the cargo being transported, the freight combination used, and the planned route. The permit may be permanent, temporary, or apply to a single passage of an oversized vehicle. The route is approved only if all specified technical and formal requirements are met as indicated by [15] and as regulated by the Sejm Rzeczypospolitej Polskiej [13]. One of the key conditions for obtaining a permit for non-standard freight operations is the proper technical condition of the road along the planned route. The roadway must not contain any damage, such as broken or collapsed sections, and the vertical and horizontal roadway clearances must be adapted to the dimensions of the freight combination. The transit route should ensure the safety and efficiency of transportation and must not cause significant traffic obstruction. The technical condition of the buildings and structures in the immediate vicinity of the planned route is also important - they must allow the passage of an oversized load in compliance with current building codes. When the route involves crossing engineering structures, especially bridges, it is necessary to carry out a detailed analysis of the technical condition of their load-bearing elements, such as girders or piers, which will be subjected to loads during

transportation as indicated by [15] and confirmed by the General Directorate for National Roads and Motorways [4]. When planning non-standard shipments, in addition to the technical condition of the pavement, road infrastructure elements, and the structural design of the roadway itself must also be taken into account. In particular, parameters such as lane width, curve radii, as well as height and width limits in the area of overpasses, bridges, and tunnels are analyzed. Existing infrastructure objects such as road signs, lighting poles, roundabouts, pedestrian refuges, lane-splitting traffic islands, traction grids, and railway networks are also important. In order to minimize the risk of delays or other disruptions to cargo shipment, it is necessary to obtain information in advance about planned road repairs on the sections that are part of the planned route. In situations where the route requires interference with the road area, the team responsible for freight completion is obliged to take measures to temporarily remove infrastructure obstacles, such as road signs, traction elements, or roundabouts. These activities, which include dismantling, securing, and restoring the elements in question to their original technical condition, are carried out by the transportation company on its own and at its own risk. Prior to the freight shipment, it is necessary to prepare a detailed report, taking into account all the measures required to ensure collision-free, safe, and law-compliant passage along the entire length of the planned route. The document should include an analysis of potential hazards and proposals for solutions to minimize risks for all traffic participants. Due to the complexity, time-consuming nature, and high costs of preparing and carrying out this type of operation, oversize shipments can cause significant impediments to general traffic. As a result, their implementation usually takes place between 10:00 pm and 6:00 am, reducing the impact of transportation on the ongoing operation of road infrastructure [1, 3]. The authority authorized to issue a permit for the passage of a non-standard vehicle may specify a number of additional conditions aimed at ensuring safety and minimizing traffic disruption. These include, among other things, the obligation to pilot the vehicle in accordance with separate regulations, or additional guidelines for securing infrastructure located in the road lane, which are established in cooperation with the relevant road managers. Another condition may be time restrictions on traveling on sections of the roadway intended for the opposite direction of traffic. In the case of crossing engineering structures, such as bridges or overpasses, it is also possible to impose additional requirements, including limiting the speed of passage or completely halting the movement of other vehicles for the duration of the passage of the oversize freight combination. All these measures are aimed at guaranteeing the safety of road structures and other infrastructure users [15].

The traffic regulations characterize in detail five categories of permits for non-standard transports. The following Table 1 summarizes the most important information on the categories of permits for the passage of a non-standard road transport combination according to the issuing authorities, the characteristics of the means of transport adopted, and the type of roads constituting the adopted route.

Obtaining the appropriate permit for the passage of a non-standard vehicle combination requires the payment of a fee, depending on the category to which the shipment in question belongs and the validity period of the documents issued. Between 2014 and 2021, there was a significant increase in the number of applications for non-standard transportation permits. Table 2 below summarizes key data on the scale of this phenomenon.

Analysis of the collected data shows a steady increase in the number of applications submitted, which rose from 13,762 in 2014 to 31,519 in 2021. At the same time, the number of permits issued grew, but the rate of growth was significantly lower, which translated into a decrease in the percentage of permits issued in relation to the number of applications submitted – from 87.1% in 2014 to 48.6% in 2021. The trend indicates an increasing share of applications that were either denied or left unresolved. From 2018, however, a renewed increase in the number of permits issued can be observed. From 2019, the relationship between the number of permits issued and the number of applications processed became increasingly unfavorable, which may indicate increasing administrative difficulties in organizing non-standard cargo transport. Despite the declining share of successful applications, the total value of fee revenues showed a significant increase - in 2014 it was about PLN 15.2 million, while in 2021 it exceeded PLN 25.6 million. Based on the financial data presented by the General Directorate for National Roads and Motorways [5] it can be deduced that the implementation of the transport licensing procedure is increasingly important in economic terms. This phenomenon may be a consequence of the increasing number of applications submitted, changes occurring in the settlement structure, or modifications made to existing legislation. The highest value of income was registered in 2021 and accounted for almost 18% of the total amount of fees over the entire period analyzed. In other years, the share remained between 10 and 14%.

Table 1. Summary of categories of permits for the passage of a non-standard freight combination, according to the General Directorate for National Roads and Motorways (2024a)

Permit category	Issuing authority	Characteristics of the non-standard freight combination	Types of roads on which the passage may take place
I	County governor (starost)	The length, height, actual weight, and axle loads of the vehicle do not exceed the permissible values. The width can be up to 3.5 meters.	Public roads, excluding expressways and highways
II	County governor (starost), head of the customs and tax office	The actual total weight and axle loads of the vehicle do not exceed the permissible values. The width can be up to 3.2 m, while the height can be up to 4.3 m. The length of a road set may not exceed 15 m for a single vehicle and 23 m for a combination of vehicles.	Public roads
III	General Director of National Roads and Highways, head of the customs and tax office	The actual total weight and axle loads of the vehicle do not exceed the permissible values. The width can be up to 3.4 m, while the height can be up to 4.3 m. The length of a road set may not exceed 15 m for a single vehicle, 23 m for a combination of vehicles, and 30 m for a combination of vehicles equipped with torsion axles.	National roads
IV	General Director of National Roads and Highways	The vehicle's axle loads do not exceed the permissible values. The height may be up to 4.3 m. The length of a road set may not exceed 15 m for a single vehicle, 23 m for a combination of vehicles, and 30 m for a combination of vehicles equipped with torsion axles. The width can reach a maximum of 3.4 m for a single carriageway road and 4 m for a dual carriageway road of class A and S. The total actual weight can be up to 60 t.	Public roads
V	General Director of National Roads and Highways, president of a city with county rights	Dimensions and actual gross weight exceed the values listed in categories I-IV. The vehicle's axle loads are higher than allowed.	Roads designated based on the route indicated in the permit

Table 2. Number of non-standard cargo transportation permits issued between 2014 and 2021, according to the General Directorate for National Roads and Motorways (2024b).

Year	Number of applications processed	Number of permits issued	Number of permits issued [%]	Value of revenues from fees paid [thousand PLN]
2014	13,762	11,986	87.1	15,193.9
2015	15,589	13,498	86.6	18,197.7
2016	13,544	11,108	82.0	14,550.4
2017	15,294	11,904	77.8	15,701.2
2018	15,880	11,753	74.0	16,198.5
2019	19,445	12,852	66.1	18,230.1
2020	22,945	13,192	57.5	20,444.9
2021	31,519	15,305	48.6	25,619.9

1.2 Analysis of the current state of affairs in non-standard transportation

Today's non-standard transportation, which is an indispensable part of the growing economy based on large-scale infrastructure and industrial investments, is one of the most demanding forms of logistics activity. The organization of this type of transport involves overcoming numerous difficulties that arise both at the stage of planning the route and during the execution of the transport itself. These problems are primarily due to the inadequacy of the road infrastructure, the complexity and time-consuming nature of administrative procedures, and the lack of standardization of existing regulations at the national and international levels [2, 7]. This chapter discusses the key barriers faced by oversize transport operators, highlighting their impact on the entire logistics process. The analysis was based on a review of available sources on the practical aspects of planning and obtaining permits, as well as the technical requirements for carrying out transportation, with particular attention to the specifics of the sector's operation under domestic conditions and in the context of European regulations. Difficulties related to the organization of non-standard transport operations are generated already at the stage of planning the passage route. The priority of any transport is to maintain an adequate level of safety, both for all road users and the cargo itself. Due to the non-standard dimensions and the weight of the transported object, which often exceeds acceptable standards, there is a risk of collision with elements of the road infrastructure. In order to prevent such problems, appropriate detours should be planned to avoid sections of the route that are impassable for a given road combination. Such obstacles may include, above all, excessively narrow passages, low bridges or overpasses, as well as uneven road surfaces that may affect the stability of the vehicle. Currently, there are no transportation corridors that are entirely suitable for non-standard transportation. As a result, the actual distance between the sending point and the destination may be much shorter than the length of the chosen route. The process of planning a non-standard route is also time-consuming due to the lack of publicly available data on the parameters of specific bridges or overpasses, the height of flyovers, or various types of restrictions occurring on individual sections of the road in real time [2, 16]. In practice, the logistician in charge of selecting the appropriate route relies on the road conditions prevailing on the day of the analysis. Typically, information regarding the current situation on the road changes significantly over the course of a year, in which steps are taken to prepare a given road combination for the passage from an administrative and technical perspective. As a result, it is necessary to adjust the shipment offer, which also affects the final cost of the entire operation, as noted by SCHWERLAST A.L. [11].

Another important problem is the discrepancy between the declared technical condition of roads and the actual condition of certain sections of the route. There are cases when the administrator of a particular road provides incorrect information on this subject, which translates into a risk of malfunction over the course of the passage. The operator responsible for non-standard transport is obliged to cover the costs of damage caused to the road surface as a result of carrying out the shipment. To avoid such problems, a team of pilots must make a preliminary drive along the route, inspecting the road surface from a technical point of view. As a result, the transportation company has a list of the actual obstacles located along the route, as well as the physical parameters of the roadway. This activity, on the other hand, is very time-consuming, which means that errors in conducting the analysis in question are usually not tolerated. The team performing the task must consist of experienced specialists who are highly meticulous and familiar with the specific requirements of the particular transport operation. Each increase in the route length proportionally increases the cost of freight transport as emphasized by Barcik [1], Syganiec-Marszewska [16], and regulated by the Ministry of Infrastructure [8].

In order to complete the operation of non-standard freight transport, it is also necessary to select a special means of transportation that will enable the order to be carried out, based on the dimensions and weight of the cargo to be transported. The oversized object must be adequately secured to the vehicle, and it must be secured against any movement, using the available fastening devices. The process of securing cargo must meet all the requirements included in the intended standard. The driving route should be precisely planned based on the principle of the shortest driving time and the most optimal road conditions. The analyses should take into account the need for costly expert evaluations of the technical condition of engineering structures located along the various stages of the route. Non-standard freight operations should take place at night, in compliance with safety rules, driving schedules, and also with the breaks taken by the team involved. Having carefully analyzed the most important issues to be taken into account when organizing the transport of non-standard cargo, it can be concluded that this type of transport is one of the most time-consuming and complicated. Proper preparation of a road set for driving requires a high degree of precision and the integration of a number of factors responsible for safety, as well as the adaptation of the means of transport

to the current conditions of the chosen route. Additional personnel are also involved in the transport operation, including a team of pilots and technical support staff, without whom the safe transport of non-standard vehicles would be impossible as noted by SCHWERLAST A.L. [11] and emphasized by Galor [3]. Oversize transport can be carried out only after obtaining the appropriate permit. Over the past few years, an upward trend in demand for non-standard transportation permits can be observed. However, current administrative procedures pose another problem for the logisticians handling the orders in question. The existing document templates are limited in terms of functionality and the comprehensiveness of the information they contain. Carriers are obliged to apply for permits for different vehicle configurations, which is the reason for starting separate administrative proceedings. The mode of this process follows directly from the "Traffic Law" Act, as reported by the General Directorate for National Roads and Motorways [6] and regulated by the Sejm of the Republic of Poland [13].

It is also important to emphasize the fact that it is necessary to obtain a permit for the passage of a non-standard vehicle each time, even if it is for the same logistical operation. The multiplicity of all regulations poses numerous problems for both new carriers entering the market and transport companies with many years of experience. In this industry, it is necessary to analyze all the regulations and the relationships between them precisely. An additional difficulty is the type of road on which the vehicle passes during operation – applications for non-standard passage permits should be submitted to the authorities responsible for the particular type of road. In fact, it involves an extremely time-consuming administrative process (Skowrońska & Kołodziejczyk, 2020).

Once all planning activities related to the approval of the final route have been completed and the organized transit has received the necessary permits, the team involved can begin the operation. At this stage, another serious problem associated with the transport of oversized cargo can be identified-inadequate urban infrastructure, the reconstruction of which significantly prolongs the entire logistics operation. Intersections with circular traffic are increasingly being designed in an "ornamental" way that does not necessarily relate to the practical possibilities of using the traffic space in question. Examples include flower beds, small buildings, shrines, or sculptures placed in the middle of a traffic circle, which is precisely where a long-loaded vehicle passes through. The disassembly and reassembly of said components consumes another valuable working time of the technical team involved, as discussed by Wierzbicka and Kmiecik [18] and highlighted by TM Transport–Spedycja [17].

Non-standard cargo transportation also faces problems at an international level. The various regulations in force in the European Union countries differ and sometimes even exclude each other. In addition to the existing directives regulating the scope of documentation to be held, as well as the correct marking of special vehicles; on the territory of the individual member state, it is necessary to comply with internal legal regulations on, among other things, the rules of transporting non-standard loads, the amount of insurance rates, as well as specific guidelines for the registration of an oversized road combination. This represents a significant constraint, as well as the additional time required to plan an international non-standard transit [14].

2. Description of research methodology

2.1. Characteristics of the respondent group

Thirty-four companies operating in the non-standard transport sector took part in the survey: SCHWERLAST Aleksandra Ledwig, Moto-West Transport Sp. z o.o., TRANSANNABERG Sp. z o.o., Miś Transport i Spedycja Sp.j., Peter-Star Sp. z o.o. i Sp. k., Kompas Spedycja Sp. z o.o., XXL-Transport, New MBK Sp. z o.o., Letniskowo Sp. z o.o., Mazurskie Przedsiębiorstwo Produkcyjno-Budowlane J.W. "ŚLEPSK" Józef Wiszniewski, Bracchi Transport i Logistyka, Transport i Spedycja Międzynarodowa "Kadam" Karasiński Adam, AGMAR Marcin Nogowski, AJ HEAVY TRANSPORT Adrian Jakubowski, FHU Kontrans Krzysztof Parzych, KOLB Sp. z o.o., MPL Logistics Sp. z o.o., ZUH ADA, GODBAN Engineering Company Mateusz Banaś, SPED-TRANS Sp. z o.o., Transport Company "PORJOT-BIS" S.c., FHU Pomoc Drogowa "BARTEX" Bartłomiej Ziemann, BEDMET Sp. z o.o. i Sp. k., DB-PRO Sp. z o.o., JKG Transport Sp. z o.o., MIMB Trans Magdalena Barwińska, TRANSDOR Dorota Chlechowicz, XETA Włodzimierz Krakowski, KRUK-TRANSPORT, PANAS TRANSPORT Sp. z o.o., Famat Serwis Sp. z o.o., ADAŚ-Trans Adam Izdebski, SZYN-TRANS Krzysztof Szynklewski and WRÓBEL PERMITS Sebastian Wróbel.

In total, the survey covered fifty-two respondents actively involved in operational, technical, or managerial activities, both nationally and internationally. Professionals with many years of experience were the dominant group - 63% of survey participants declared more than five years of work experience in the industry under consideration. The remaining respondents, on the other hand, are those with less time on the job, which made it possible to gather diverse perspectives - both from employees who are well acquainted with the

practices of the system and those just joining the sector's structures. The chart below shows the share of respondents according to length of service.

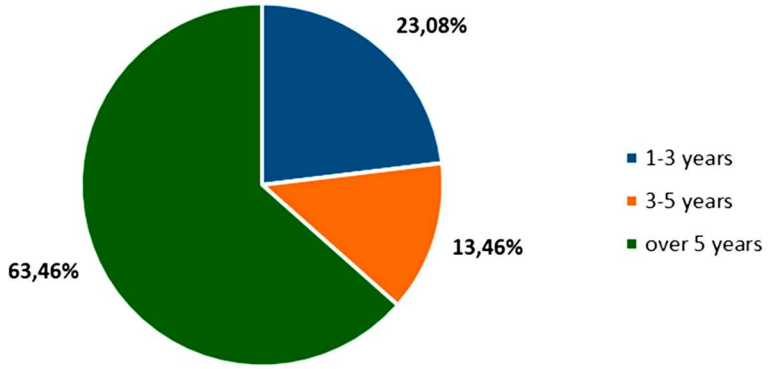


Fig. 2. Percentage of respondents according to length of service

This carefully selected research group enabled a multifaceted assessment of the current organizational and systemic conditions related to the implementation of oversized transport in Poland. Respondents represented a broad spectrum of professional functions, covering both operational and management levels. Participants in the survey included transport coordinators, dispatchers, permit specialists, drivers, escort members, as well as logistics, administration and sales staff, among others. The structure of respondents also included those in management and decision-making positions, as shown in Figure 3.

It should be noted that some of the participants have several parallel roles in the organization, which further enriched the quality of the data obtained - their responses were therefore based on multifaceted and interdisciplinary experiences. This research design enabled a comprehensive analysis of the issue of non-standard transportation, taking into account different levels of responsibility and scopes of duties.

In order to comprehensively identify organizational, administrative, and infrastructural barriers related to the implementation of non-standard transportation in Poland, this article is based on an analysis of the literature on the subject. In addition, a survey was conducted to obtain both quantitative and qualitative data from representatives of the industry under consideration. The research process was complemented by cooperation with Schwerlast A.L., which enabled verification of the selected assumptions and deepening of the analysis, thanks to consultations on the operational specifics of the transports carried out.

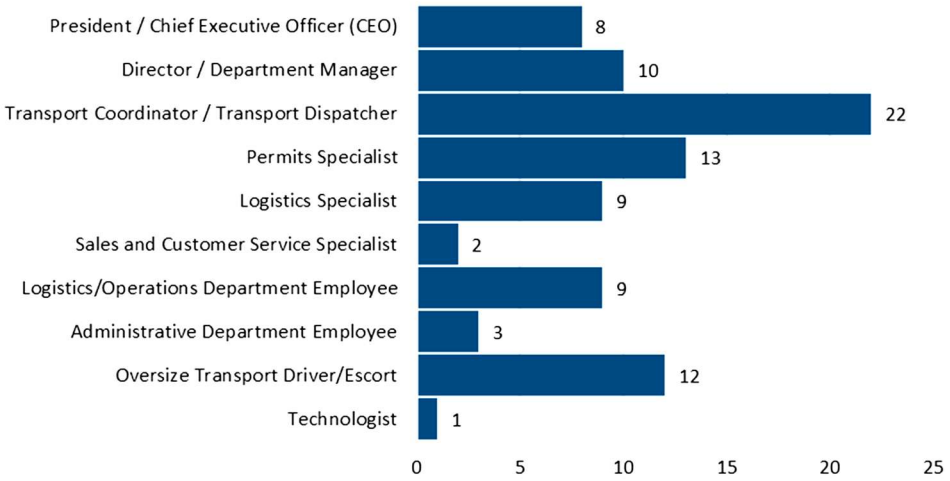


Fig. 3. Structure of respondents by position held

2.2. Design of the survey questionnaire

The research questionnaire was designed to identify the complexity of the issue under study and to reflect its multidimensional aspects. The survey tool included 20 questions, of which 10 were closed and 10 were open. The data collection process lasted from May 26 to August 11, 2025. Closed-ended questions made it possible to obtain quantitative material in the form of statistical data, while open-ended questions enriched the results through qualitative analysis based on the free statements of respondents.

The answers provided are a valuable source of information on the actual experiences and subjective assessments of those directly involved in the organization and implementation of non-standard transports. Analysis of the collected data enables the identification of the most frequently recurring problems, critical opinions, and demands for change formulated by specialists in the organization of non-standard transportation. These statements, juxtaposed with statistical data, provide a more accurate understanding of the specific functioning of the areas studied. The survey form was divided into two parts and designed to cover three key topic areas relevant to the organization of non-standard road transportation. Part one included questions aimed at identifying the main problems of the sector, including:

1. An assessment of the state of the country's road infrastructure;
2. Characteristics of cooperation with administrative units;
3. Efficiency of existing procedures for obtaining transport permits.

The second part of the survey provided an open space for respondents to formulate recommendations and suggestions for actions to optimize the listed organizational impediments.

The collected data was subjected to quantitative and qualitative analysis. Quantitative analysis was carried out using basic statistical methods, which made it possible to identify dominant responses, identify significant trends, and present the distribution of ratings based on the five-point scale used in the survey, in which a value of 1 corresponded to a very low level of satisfaction, while a value of 5 corresponded to a high level. Qualitative data, obtained through open-ended questions, was subjected to content analysis. In the course of compiling the results, the main themes and problems that most often appeared in the respondents' statements were identified. This approach enabled the synthesis and in-depth interpretation of key issues within the context of transportation practice.

3. Research results analysis

3.1. Adaptation of the Polish road infrastructure for the implementation of non-standard transports

Adequate adaptation of the road infrastructure is one of the fundamental conditions for the efficient implementation of non-standard transportation. As part of the survey, participants were asked to assess the extent to which the national road network is adapted to the specifics of oversize transports. The collected data enabled the formulation of a comprehensive picture of the current state of the road infrastructure, identifying the most frequently indicated barriers and constraints that hinder the effective organization of this type of transport.

An analysis of the responses shows that the largest number of respondents - 28 to be exact, representing 53.8% of the entire survey sample - rated the level of adaptation of the country's road infrastructure to accommodate oversize transport at a score of 3 on a five-point scale, indicating a moderate degree of satisfaction with current solutions. Thus, the arithmetic mean was 2.94, placing the overall rating below satisfactory. Only one survey participant gave the highest rating. At the same time, two respondents rated Polish infrastructure the lowest, signaling a deep deficit in adapting the road network to the needs of non-standard transport. Although some survey participants recognize the positive changes associated with the modernization of road infrastructure, the overwhelming majority of responses included criticism of structural barriers that significantly limit the ability to carry out oversize transports efficiently. The most frequently reported infrastructure barrier was an insufficient number of dedicated parking spaces and technical bays. This fact significantly complicates the process of planning stops and rest periods for drivers, especially on older sections of national and regional roads. Among further difficulties, overpasses and tunnels that were too low were often singled out, as well as the limited load-bearing capacity of engineering structures. It was emphasized that the technical condition of Polish bridges, flyovers, and overpasses is deteriorating, as a result of which their load-bearing capacity is being reduced, which in many cases eliminates the possibility of passing road combinations of non-standard tonnage. Another significant organizational obstacle is the lack of a system

containing technical information on Polish bridge structures, which results in numerous costly expert assessments of the same structure. Attention was also drawn to technical obstacles, which included, among others, unsuitable roundabouts, traffic islands, energy-absorbing barriers, and road markings, which often prevented efficient dismantling. These solutions not only reduce the smoothness of transit but also force the search for alternative routes. Respondents pointed out that the current procedures for obtaining approvals for temporary modifications to the road lane or infrastructure elements are overly complicated, significantly lengthening the process of arranging a crossing. They also pointed out the difficulties associated with narrow roads, sharp curves, lack of proper route signage, and limited ability to effectively plan detours, especially in the event of unforeseen road repairs. In addition, attention was paid to the variation in the quality of infrastructure - modern sections of expressways contrast with local roadway sections, which are still unsuitable for the specifics of oversized transport. Particularly problematic areas included, among others, the provinces of Silesia, Podlasie, Świętokrzyskie, Lublin, Małopolska, and Podkarpackie, where the condition of roads and bridges significantly limits the possibility of carrying out oversize transports. Infrastructure problems were also identified in the northeastern part of the country, particularly in the Warmian-Masurian province, where tight traffic circles, low overpasses, and limited availability of alternative routes were found. Organizational difficulties were also pointed out with regard to urban agglomerations such as Gdansk, Gdynia, as well as the Upper Silesia and Zagłębie Metropolitan Area, and selected sections of national roads and highways - especially the S19, A4, and A2 - where frequent renovations and the need to conduct multi-stage arrangements with numerous independent infrastructure managers make it much more difficult to organize transportation. The most frequently highlighted sections were the A4 highway between Katowice and Krakow, and the S19 expressway between Lublin and Rzeszow. Some of the contributions pointed out that the difficulties encountered are nationwide and are due to the lack of a coherent system structure.

Despite the aforementioned limitations, some respondents emphasized the positive aspects of the changes taking place, especially in terms of improved capacity and reduced travel times, which were directly linked to the expansion of the Class A and S road network. A reduction in the costs associated with adapting infrastructure to the needs of oversize traffic was also observed.

Figure 4 presents the distribution of ratings given by survey participants regarding the adaptation of Poland's road infrastructure for non-standard traffic.

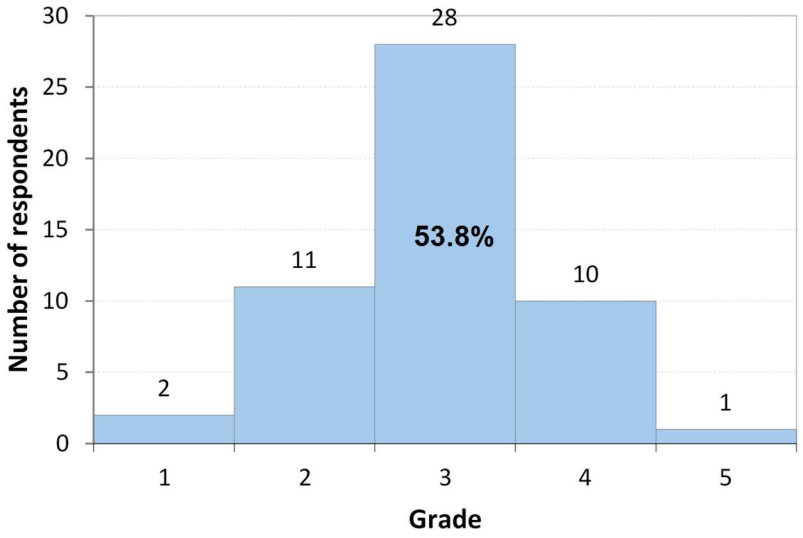


Fig. 4. Respondents' assessment of the adaptation of the Polish road infrastructure for the implementation of non-standard transportation

3.2 COOPERATION WITH ADMINISTRATIVE UNITS

Cooperation with administrative units responsible for issuing transportation permits was identified at a similarly low level of satisfaction as road infrastructure. The largest group of respondents indicated a rating of 3, accounting for 42.3% of all responses. In comparison, 25% of survey participants assigned the cooperation in question a rating of 2, and 13.5% expressed satisfaction, giving it a score of 4 out of a possible 5. The arithmetic average of the scores obtained was 2.73, which indicates a general dissatisfaction with the quality of communication and the efficiency of administrative institutions that play a key role in the process of organizing oversized transports. Attention was drawn to the overload of duties and insufficient knowledge of the specifics of the implementation of specialized transportation. The lack of a replacement system for those responsible for issuing and signing administrative decisions paralyzes proceedings in their absence. Among the significant organizational difficulties, the lack of openness of some institutions to technological progress, which would enable the optimization of the time needed to conduct proceedings, was also mentioned. The respondents also emphasized that a significant portion of non-standard transport in Poland is carried out illegally or bypasses administrative procedures, which affects the attitude of authorities toward carriers. As a result of this phenomenon, it often becomes challenging to cooperate with entities that seek to carry out shipments in full compliance with current regulations. Communication with administrative units was assessed as insufficiently effective, due in part to the use of outdated contact methods such as fax and paper correspondence. Respondents signaled the need to implement a unified, integrated electronic system to allow online submission and tracking of applications. Today, the lack of such a solution results in officials being required to manually transcribe data from applications into internal systems, which prolongs processing time and increases the risk of errors. The dispersion of administrative authority and the lack of uniform standards were also frequently raised problems. Differences in documentation requirements, processing times, and forms used by different road managers lead to confusion and delays in transportation. In a small number of cases, respondents pointed to positive experiences with selected local government units, which were characterized by a professional approach, as well as greater flexibility and openness to cooperation. It was emphasized, however, that the quality of the collaboration in question varies and depends on the specific region of the country, as well as on the experience of a given institution in the field of non-standard transportation. Nevertheless, the overall picture indicates an urgent need to reform the permit issuance system and to digitize and standardize procedures in this area.

Figure 5 presents the distribution of ratings given by survey participants on cooperation with administrative units in the context of the implementation of non-standard transportation.

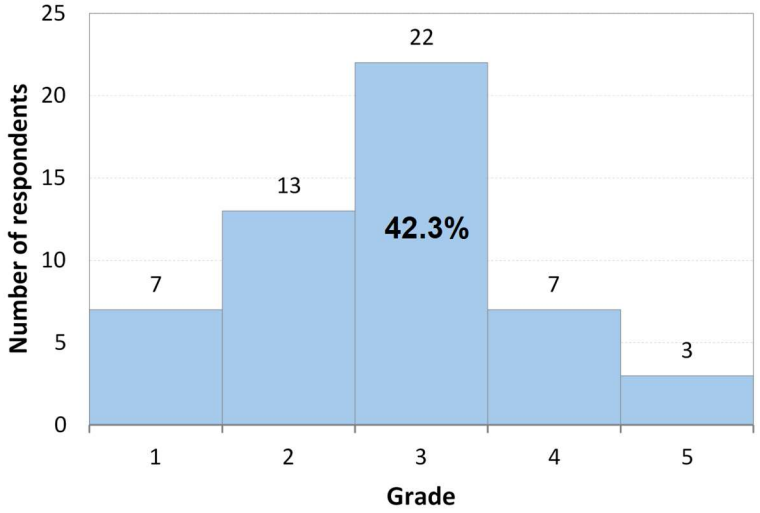


Fig. 5. Respondents' assessment of cooperation with administrative units in the context of the implementation of non-standard transportation

3.3 PROCEDURE FOR OBTAINING NON-STANDARD TRANSPORTATION PERMITS

Another area assessed as part of the survey was the procedure for obtaining permits for carrying out oversize transports. An analysis of the distribution of ratings indicates that respondents perceive this process as the most problematic of all aspects analyzed. The most frequently given rating was three on a five-point scale, which was indicated by 38.5% of survey participants, while as many as 23.1% of respondents rated the procedure at the lowest level. The arithmetic average score was 2.52, which is lower than that for road infrastructure and cooperation with the administration, indicating a clearly unsatisfactory level of efficiency in the current procedural arrangements. The respondents emphasized that the current procedures are outdated, with an example being the need to send documents by traditional mail or fax. An additional barrier is the requirement to have the original document on a strictly accountable form, which means that it must be collected in person and physically handed over to drivers. Solutions related to the use of the ePUAP platform, which, instead of streamlining the process, require the use of multiple electronic signatures, were also criticized. With a larger number of applications, these solutions prove even less efficient than faxing documents. It was noted that decisions issued digitally are unclear and are generated as separate files with attachments, leading to disorganization and hindering their practical use. The lack of a central electronic platform to handle applications comprehensively is therefore seen as one of the main factors slowing down and complicating organizational efforts. The respondents also pointed to the system's lack of flexibility in making changes to permits already issued - for example, regarding vehicle registration numbers, which, in practice, generates additional organizational difficulties. In the responses of survey participants, the significant differences in the waiting time for issuance of a permit in Poland compared to neighboring countries were repeatedly emphasized. Under Polish conditions, the procedure can take as long as two to three weeks, while in other European countries, permits are usually issued within 24 hours, and the maximum waiting time rarely exceeds five working days. Another significant problem with the current system is the lack of mechanisms enabling real-time monitoring of the status of proceedings, which often forces carriers to engage in additional interactions with individual administrative units to obtain information about the current stage of their case. The respondents pointed out that even uncomplicated applications are subject to time-consuming procedures due to the need for numerous consultations, which significantly lengthens the entire decision-making process. Some respondents also drew attention to the problem of illegal non-standard transports, which are carried out in disregard of current procedures and permits. This phenomenon not only reduces the level of road safety but also undermines the principle of equal competition in the transportation industry. Individual opinions indicated a relatively smooth process for obtaining permits of categories I through IV, but particular difficulties were identified in the case of category V, the issuance of which requires multi-stage arrangements with multiple institutions, adding to the complexity of the procedure.

Figure 6 presents the distribution of ratings given by survey participants on the procedure for obtaining non-standard transportation permits.

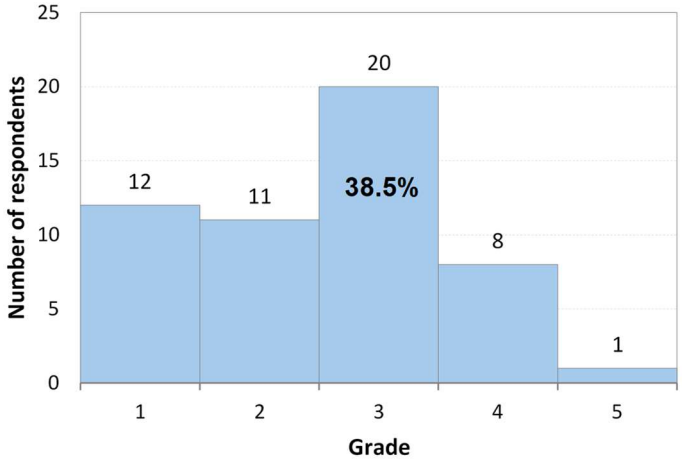


Fig. 6. Respondents' assessment of the procedure for obtaining non-standard transportation permits

The results of the survey clearly indicate that the biggest challenges in the organization of oversize transport in Poland are systemic and require coordinated legislative and investment activities. Only simultaneous improvements to administrative procedures and technical infrastructure can contribute to increased efficiency, safety, and predictability in such complex logistics operations.

4. ASSESSMENT OF OPPORTUNITIES TO IMPROVE IDENTIFIED BARRIERS TO THE DEVELOPMENT OF NON-STANDARD CARGO TRANSPORT

Qualitative and quantitative data collected in the course of the study made it possible to identify a number of recommendations formulated by transportation industry specialists, aimed at improving organizational and administrative processes related to the implementation of non-standard cargo transportation in Poland.

Among the most frequently mentioned demands, respondents pointed to the need to implement an integrated electronic system that allows both the submission and monitoring of permit applications in real time, as well as the automatic transmission of requests to the relevant road managers. Access to up-to-date infrastructure data would also be an important element of this solution. According to the survey participants, it could significantly improve the process of planning and executing transport operations. The proposed system should integrate all stages of administrative proceedings, ensuring their transparency, predictability, and reduction in the time it takes to handle formal procedures. In order to demonstrate the validity of the proposed solution, the respondents referred to examples of systems implemented in other European countries, perceived as more modern and effective in handling non-standard cargo operations. In particular, the functioning of the German VEMAGS system and the Lithuanian automatic routing system were highlighted, which, thanks to their complete digitization, high degree of automation, and transparency of procedures, contribute to a significant reduction in the waiting time for administrative decisions and the number of formal errors. The Lithuanian platform additionally allows for adjustment of the chosen route based on data on constrictions, repairs, or height and tonnage restrictions, making it a particularly advanced tool to support freight planning. Similar solutions are also in place in the Netherlands, Belgium, Latvia, and Slovakia, where the transport organizer has access to an app that contains information on the current road network, among other things. Concerning the indicated templates, the need to move away from the obligation to submit original documents in paper form was particularly emphasized, which would promote greater efficiency and predictability in decision-making processes. It was also stressed that the efficiency of the administrative system had clearly deteriorated after the COVID-19 pandemic. Despite the temporary introduction of tools enabling remote handling of organizational matters, many institutions have reverted to traditional, paper-based forms of documentation, which was assessed as a regression, significantly hampering the efficient implementation of procedures. These experiences have definitely highlighted the need for consistent digitization, as well as the automation and standardization of administrative activities at the national level.

The software under consideration could include all databases on the technical condition of roads, the layout of road infrastructure, the dimensions of roadways, intersections, railroad crossings, as well as the parameters of all bridges. The system under consideration should also be based on up-to-date maps of the Republic of Poland, which would allow precise planning of the route of travel. The most significant technological advancement of recent years is undoubtedly the development of artificial intelligence, which, as it continues to improve, can perform increasingly complex operations. Following this line of thinking, it is possible to create a prototype in addition to the computer program in question. Artificial intelligence could design proposed non-standard routes based on the starting point, destination, and the principle of the shortest possible route. In addition, the program user could enter data on the parameters of the non-standard road combination and the maximum turning radius, so that the system could adjust the selected route and plan the necessary detours to enable a given trip. As a result, the document completed by the carrier could automatically go to the appropriate unit responsible for issuing transport permits in a given area of the country. The relevant application should also provide for the possibility of finalizing settlements for issued permits, so that the entire administrative procedure can be comprehensively centralized in one place. The respondents also called for digitizing the parameters of the road network in such a way that permits for the passage of non-standard convoys that fall within the accepted dimensional and tonnage ranges could be issued in automatic mode. At the same time, transports exceeding these values would be subject to detailed analysis by a relevant official. As an example of such a solution, they pointed to the system in place in the UK, where for shipments meeting certain parameters - for example, a length of 30 meters, a width of 5 meters,

and a weight of 150 tons - a permit is issued immediately, with an expiration date of up to three days. This period is set aside for possible comments from infrastructure managers, allowing the process to begin quickly while maintaining institutional control. Such solutions could significantly optimize working time, both for the requesting carriers and for the units issuing non-standard transit permits, which could reduce the number of illegal transports exceeding the indicated standards. The platform could automatically collect statistical databases on the number of applications submitted, the type of cargo transported, and the means of transport used, as well as the non-standard cargo transport permits issued in a given calendar year, which will definitely simplify the observation of the demand for this type of transport over the years. As a result of the information gathered on an ongoing basis, transportation specialists would be able to accurately forecast Poland's economic progress in terms of the development of non-standard cargo operations. The assumptions presented are in line with the concept of sustainable development.

The respondents also stressed the importance of taking into account the demands formulated by associations of employers in the oversize transport sector, pointing to the need for regular dialogue between the administration and industry representatives. In addition, attention was paid to the need to improve logistics processes by building additional parking spaces dedicated to non-standard combinations, upgrading engineering facilities, and adapting technical infrastructure to the specifics of specialized transport. They also pointed out the need to unify the regulations and guidelines used by various road managers in order to reduce discrepancies in interpretation, as well as to reduce route planning time.

However, the above-mentioned measures involve a number of difficulties and time-consuming activities that would have to be carried out for this purpose. Just creating a software prototype that meets all the objectives of this solution would require hiring experienced programmers, which translates into an initial financial outlay. Another complicated aspect would be the constant updating of the collected databases on road infrastructure, which would require regular fieldwork. Expanding the project to include a module improving administrative activities related to the process of obtaining permits would have to be included in new procedures and amendments to the law, which are complex legislative measures. If the project were released for actual use, training would be required for employees, introducing them to the ways of using the resulting computer system. The above activities should be covered by a guarantee of continuous monitoring of their correctness, as well as the processing of incoming applications. In order to achieve the most effective result, it would be worthwhile to establish cooperation with representatives of experienced companies dealing with non-standard transportation services, government agencies, international transportation associations, offices dealing with the processing of permit acquisition, as well as the Road Transport Inspection. The whole undertaking would generate high organizational and implementation costs.

SUMMARY AND CONCLUSIONS

Oversize transportation is a time-consuming process involving an extensive team of skilled people. Thus, the development of this industry is generating new jobs, as well as increasing the capacity of other branches of the state economy. A critical approach to the execution of non-standard transport orders is vigilance, as well as the meticulousness of the actions performed as emphasized by SCHWERLAST A.L. [11].

The conducted literature review, cooperation with Schwerlast A.L., as well as the completed questionnaire research, enabled a comprehensive identification of administrative, organizational, and infrastructural barriers that significantly affect the operation of the oversize transport sector in Poland. An analysis of statements made by specialists, primarily representing companies providing international transportation services, revealed a number of systemic imperfections that limit the efficiency, predictability, and safety of transportation processes. The results clearly indicate that the effective implementation of non-standard transport operations requires not only infrastructure investment, but also fundamental changes in the way procedures related to this type of transportation are organized and handled. Key areas for intervention include:

- the need to centralize the system for handling transport permit applications,
- complete digitization and integration of decision-making processes,
- unification of administrative procedures nationwide,
- systemic improvement of cooperation between transport operators and road infrastructure managers.

In the area of road infrastructure, despite noticeable progress related to the expansion of the expressway and highway network, severe technical constraints still persist. The most commonly identified barriers include:

too low viaducts and tunnels,
- bridge structures with limited carrying capacity,
- lack of properly adapted technical bays and parking spaces,
- narrow traffic circles and intersections,
- elements of road markings that prevent the smooth and safe passage of oversize combinations.

Attention was also drawn to the significant disparity in infrastructure quality between modern sections of the national network and local routes, which often remain unsuitable for the specifics of this type of transport.

In light of these observations, it was considered crucial to implement an internal IT platform that would allow not only the submission and monitoring of applications in real time, but also the automatic distribution of inquiries to infrastructure managers, tracking the status of proceedings, and providing access to up-to-date data on the technical status and constraints on the routes under consideration. It was pointed out that this type of solution is already successfully operating in other European countries, in particular in Germany, where the VEMAGS system has resulted in better efficiency of non-standard transport. Other examples were the systems in place in Lithuania, Latvia, Slovakia, and the Netherlands, which provide a higher level of transparency, automation, and reduced waiting time for administrative decisions. The respondents also unanimously called for the abolition of the obligation to provide original documents in paper form and a complete shift away from analog communication channels to remote solutions. The experience during the COVID-19 pandemic proved that digital tools are feasible and bring real improvements. Therefore, the need for not only digitization but also complete automation and standardization of procedures on a nationwide scale has clearly emerged. According to the survey participants, the road infrastructure requires expansion of parking facilities for oversize convoys, standardization of regulations nationwide, modernization of bridges and engineering structures, and the construction of dedicated routes for specialized transport.

In conclusion, the oversize transport sector in Poland is currently facing the challenge of comprehensive modernization. Its success depends on coordinated legislative, institutional, and investment measures, which will include both the development of technical infrastructure and the reform of administrative procedures.

BADANIA I ANALIZA KLUCZOWYCH CZYNNIKÓW WPŁYWAJĄCYCH NA EFEKTYWNOŚĆ I BEZPIECZEŃSTWO PONADNORMATYWNEGO TRANSPORTU DROGOWEGO

W artykule przeanalizowano kluczowe czynniki wpływające na efektywność i bezpieczeństwo nienormatywnego (ponadgabarytowego) transportu drogowego w Polsce. Ze względu na rosnące zapotrzebowanie na przewóz ładunków wielkogabarytowych i ciężkich, sektor ten stał się kluczowym, a jednocześnie wymagającym elementem logistyki. W badaniu zidentyfikowano główne bariery organizacyjne, infrastrukturalne i administracyjne oraz zaproponowano kierunki systemowych usprawnień.

Badania obejmowały przegląd literatury, współpracę ze Schwerlast A.L. oraz ankietę przeprowadzoną wśród 34 firm transportowych i 52 specjalistów reprezentujących różne szczeble organizacyjne. Zarówno analizy ilościowe, jak i jakościowe wykazały, że nieefektywności systemowe znacząco ograniczają wydajność operacyjną. W artykule zaproponowano opracowanie zintegrowanej platformy cyfrowej do składania i monitorowania zezwoleń, wzorowanej na niemieckim systemie VEMAGS i litewskim systemie automatycznego wyznaczania tras. System taki ujednoliciłby standardy administracyjne, zautomatyzował wymianę danych i znacznie skrócił czas podejmowania decyzji. Respondenci podkreślali również potrzebę dialogu między branżą transportową a organami rządowymi, modernizacji mostów i infrastruktury oraz tworzenia dodatkowych zatok technicznych i parkingów. W badaniu stwierdzono, że poprawa efektywności transportu ponadgabarytowego w Polsce wymaga równoczesnych reform infrastrukturalnych, administracyjnych i legislacyjnych. Wprowadzenie ogólnokrajowych, zdigitalizowanych procedur i lepsza koordynacja między instytucjami mogłyby zwiększyć efektywność, bezpieczeństwo i konkurencyjność w tym kluczowym sektorze logistyki.

Słowa kluczowe: transport drogowy nienormatywny, ładunki ponadgabarytowe, bariery infrastrukturalne, bezpieczeństwo transportu.

AUTHOR CONTRIBUTIONS

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- software, W.Ł. and M.S.;
- validation, W.Ł. and M.S.;
- formal analysis, W.Ł.;
- investigation, W.Ł. and M.S.;
- writing - original draft preparation, W.Ł.;

- writing - review and editing, M.S.;
- visualization, W.Ł. and M.S.;
- supervision, W.Ł. and M.S.;
- project administration, W.Ł.

All authors have read and agreed to the published version of the manuscript.

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