Economic and legal aspects of using rail transport for the carriage of dangerous goods

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***Abstract*— The aim of the article is to analyse the use of rail transport for the carriage of dangerous goods, with particular emphasis on the specifics of military transport. The study presents fundamental concepts related to transport, the transport system, and the characteristics of dangerous goods. Current legal regulations and cost calculation procedures for transport are discussed. Based on a case study of an actual transport of unleaded 95 petrol, a practical logistical analysis and cost calculation were provided.**

Keywords— dangerous goods, transport costs, legal regulations, rail transport, military transport

I. INTRODUCTION

Every day, vast quantities of goods flow through the roads, railway lines, and other transport routes of Poland and the European Union. While most of these goods are subject to standard logistical procedures, certain shipments—due to their specific properties—require special attention and tailored transport technologies. These include perishable goods, oversized cargo, and hazardous materials, the transportation of which entails elevated risks. It is this latter category of goods that forms the focal point of this study. Both civilian and military transport, though differing in objectives and priorities, face similar challenges when handling dangerous goods. To ensure efficient transport operations, the military sector frequently collaborates with civilian transport operators, driven by the need to optimize costs and utilize existing infrastructure. While the civilian sector primarily focuses on public safety and environmental protection, the military must additionally account for strategic requirements such as mobility, crisis flexibility, and threat resilience. Rail transport plays a crucial role in military transport operations, serving as an indispensable component of logistics for both operational and supply shipments. In both cases, advanced procedures and modern risk-mitigating technologies are critical. Furthermore, additional legal regulations—varying by country and cargo type—aim to maximize the safety of transport participants and the environment. Economic issues are also significant - the cost of rail transport requires careful planning to ensure both the highest safety standards and cost-effectiveness.

The aim of this article is to analyse the economic and legal aspects of the use of rail transport for the carriage of dangerous goods, with particular reference to the specifics of military transport. The research problem undertaken to be solved is specified as follows: What are the specific legal requirements governing the transport of dangerous goods by rail, particularly in the context of military transport? An additional objective is: What are the main cost components associated with the transport of dangerous goods by rail and how do they affect the total cost of the operation?

The following research methods were used to develop this article: analysis of literature and legislation, induction, deduction, abstraction and inference. The research methodology adopted has enabled the research problem to be solved and provides a solid foundation for future research into this multidimensional and important issue.

II. SELECTED THEORETICAL ASPECTS OF THE USE OF RAIL TRANSPORT FOR THE CARRIAGE OF DANGEROUS GOODS

The definition of transport can be examined depending on the process-based, sectoral or scientific approach. From

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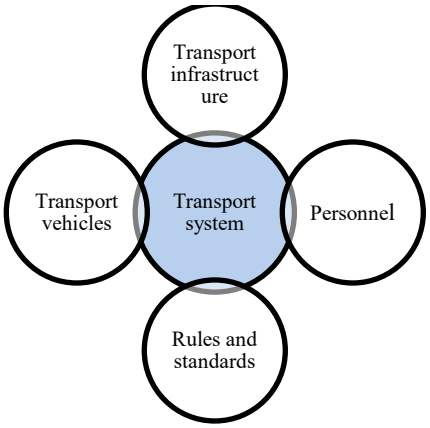
a process perspective, transport is understood as a set of activities aimed at the movement of people and goods using available means of conveyance. In the sectoral approach, transport is treated as a component of the national economy, encompassing all resources and activities involved in the execution of shipments. From a scientific standpoint, transport constitutes a distinct field of research, analysing phenomena and processes related to the movement of people and cargo in space (Kisperska-Moroń & Krzyżaniak, 2009).

Since transport is viewed as a process, its effective implementation requires the existence of an organised and coherent structure. This structure is the transport system, which constitutes an integrated whole composed of interconnected elements. The interaction of these elements enables the execution of processes related to the movement of people and cargo between specified origin and destination locations (Kacperczyk, 2009). The key components of this system are illustrated in Figure 1.

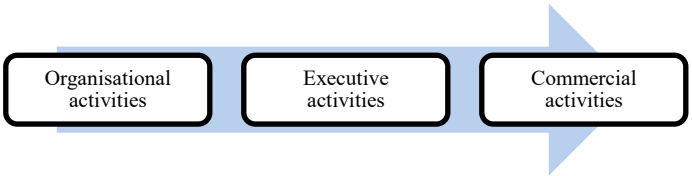
FIGURE 1. COMPONENTS OF THE TRANSPORT SYSTEM



Source: Own elaboration based on: Kacperczyk, R. Środki transportu Część 1; Difin: Warszawa, 2016; p. 23.

The transport system provides the organisational and technical foundations for the transportation process. It is understood as an ordered sequence of consecutive operations aimed at moving people or cargo from an origin to a destination point, using appropriate means of transport and available infrastructure. The components of the transport process are organised by distinguishing three main categories, as illustrated in Figure 2.

FIGURE 2. COMPONENTS OF THE TRANSPORTATION PROCESS



Source: Own elaboration based on: Stajniak, M.; Hajdul, M.; Foltyński, M.; Krupa, A. Transport i spedycja; Wydawnictwo Instytut Logistyki i Magazynowania: Poznań, 2008; p. 11.

The transport process includes organisational activities aimed at the preparation of transport, executive activities involving the physical movement and handling of the load, and commercial activities related to the formal implementation and settlement of the transport order (Kacperczyk, 2009). Accurate and consistent execution of the above-mentioned activities is crucial for proper planning of transport operations over time, as well as for ensuring an adequate level of safety and reducing the risks arising from potential hazards accompanying the movement of equipment.

Various modes of transport can be distinguished, among which rail transport holds a particularly significant position. As one of the main branches of land transport, it plays a crucial role in the movement of both passengers and freight. Due to its capacity to carry large volumes of goods over long distances at relatively low unit costs and with a high level of safety, rail transport is often used for the logistics of hazardous materials.

From a military perspective, it is worth noting military transport in particular. Its definition can be examined in both material and conceptual terms. In the material sense, it refers to the set of technical means of transportation used for moving troops, weapons, military equipment, combat resources, and supplies during both wartime and peacetime. In the conceptual sense, the term denotes the organised movement of military units or their subunits, groups of soldiers, weapons and military equipment, combat and logistical resources, as well as military shipments, based on military transport documents (Bursztyński, 2011). Military transport is characterised by mass cargo shipments, irregular frequency dictated by operational needs, the necessity of maintaining special safety precautions, and the requirement to prepare transport means for heavy military equipment and hazardous materials. Depending on their nature and purpose, military shipments are categorised into (Zieliński, Bursztyński & Drewek, 2010):

- operational transports, which includes the transportation of soldiers with their equipment,
- supply transports, relating to the transportation of armaments and military equipment as well as combat and material resources,
- evacuation transports, relating to the evacuation of redundant supplies, damaged and faulty armaments and military equipment and packages,
- mobilisation transports, used during mobilisation for the movement of persons called up for service during military mobilisation.

Given the focus of this article on the legal and economic aspects of transporting such cargo by rail, it is pertinent to provide a definition of dangerous goods. These constitute a special category of freight. The term refers to substances and articles whose physicochemical or biological properties may - if improperly transported - pose risks to human life and health, cause environmental contamination, or result in property damage and losses (Neider, 2006).

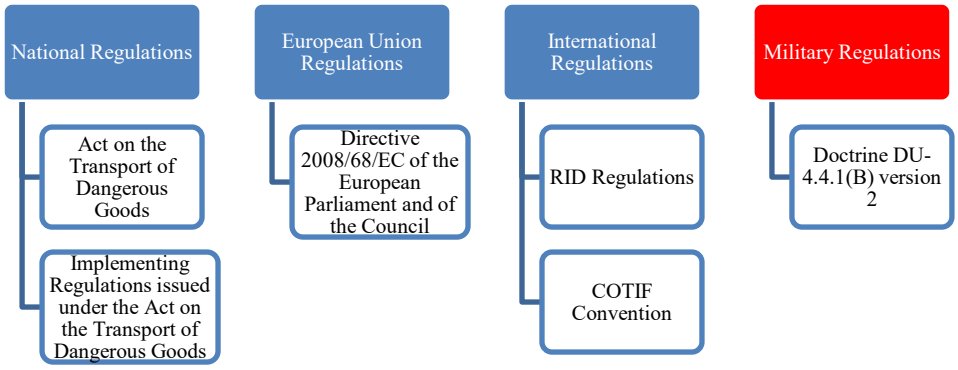
The definition of dangerous goods can also be found in Article 2 of the Act of 11 August 2011 on the Transport of Dangerous Goods. According to its provisions, a dangerous good is defined as any substance or article which - in accordance with the provisions of the ADR, RID or ADN agreements - is either prohibited from road, rail or inland waterway transport respectively, or is permitted for such transport under the conditions specified in these regulations (Dz. U. z 2011 r. Nr 227, poz. 1367).

Specialist literature contains numerous detailed and comprehensive classifications of such goods. International regulations, such as the RID Regulations, distinguish nine fundamental classes of dangerous goods (RID, 2023): (1) explosives, (2) gases, (3) flammable liquids, (4) flammable solids, (5) oxidizing substances and organic peroxides, (6) toxic and infectious substances, (7) radioactive material, (8) corrosive substances, and (9) miscellaneous dangerous substances and articles.

III. LEGAL ASPECTS OF THE USE OF RAIL TRANSPORT FOR THE CARRIAGE OF DANGEROUS GOODS

In any organisation or institution, including the transport industry, absolute compliance with certain rules and regulations is an essential foundation of operation. Accurate implementation of legal standards not only guarantees compliance with regulatory requirements, but also promotes efficient cost management and minimisation of potential risks. In the area of dangerous goods transport, particularly rail transport, adherence to strict regulations is crucial for the safety of operations, as well as for the efficiency and reliability of the entire logistics process. The transport of dangerous goods by rail, due to its specific risks, is strictly regulated by a comprehensive set of legal provisions (Łukasik, Nowakowski & Ushakov, 2007). In order to precisely define the legal requirements governing the transport of dangerous goods in rail transport, a detailed analysis of the regulations in force at both international and national levels was carried out. In the context of the international regulations governing the transport of dangerous goods, national regulations only act as a basis for more advanced measures in the implementation of the process. National regulations need to be strictly embedded within the framework of norms and standards set by international legislation (Skowrońska & Suchecki, 2022). In addition, in the context of military transport, often referred to as special transport, there are further regulations that also need to be taken into account. Figure 3 below illustrates the key regulations and legislation relating to the transport of dangerous goods, taking into account both international, national and specific military transport aspects.

FIGURE 3. LEGAL REGULATIONS ON RAIL TRANSPORT OF DANGEROUS GOODS: INTERNATIONAL, NATIONAL, AND MILITARY FRAMEWORKS



Source: Own elaboration based on ISAP data

The European Union, as an economic and political community of states, is competent to enact legislation of intercontinental scope (Rewizorski, 2011). European Union regulations governing the transport of dangerous goods by rail are set out in Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008. This directive establishes rules for the transport of hazardous materials within the European Union for various modes of transport, including rail transport. The implementation of Directive 2008/68/EC by member states is mandatory, which obliges them to implement certain requirements within the framework of national transport law.

The rail transport of dangerous goods within the European Union is governed by the RID Regulations and the COTIF Convention. The COTIF Convention (Convention concerning international carriage by rail), adopted in 1980, serves as the foundation for international rail transport regulations, including dangerous goods transportation. COTIF establishes uniform rules for international rail carriage between member states, implementing consistent provisions regarding liability, transport documentation, and operational procedures. Poland, like other EU countries, is a contracting party to this convention, enabling seamless and safe international rail transport of dangerous goods (Pietrzyk-Wiszowaty, 2016). The RID Regulations (Regulations concerning the international carriage of dangerous goods by rail) constitute the primary legal instrument governing dangerous goods transportation by rail (Kacperczyk, 2009). This document is a regulation for the international carriage of dangerous goods by rail), which details the technical and operational requirements for the carriage of these loads. The RID regulates the classification of dangerous goods, the requirements for their packaging, labelling and transport documentation. It also includes safety standards related to loading, unloading and dealing with emergency situations.

The transport of dangerous goods by rail within the territory of the Republic of Poland is regulated by the Act of 19 August 2011 on the transport of dangerous goods. In the Polish legal system there are additional legal acts supplementing the regulations on the transport of dangerous goods, which specify in detail the requirements in this respect. These are:

- regulation of the Minister of Transport, Construction and the Maritime Economy of 14 August 2012 on the form of the annual report on activities in the field of transport of dangerous goods and the manner of its completion (Dz. U. z 2023 r. poz. 24),

- regulation of the Minister of Infrastructure and Development of 7 May 2015 on obtaining the certificate of an adviser on the safety of transport of dangerous goods (Dz. U. z 2023 r. poz. 84),
- regulation of the Minister of Infrastructure of 25 October 2019 on the form of the checklist and the form of the inspection protocol (Dz. U. z 2019 r. poz. 2302),
- regulation of the Minister of Transport, Construction and Maritime Economy of 29 May 2012 on the conduct of courses on the carriage of dangerous goods (Dz. U. z 2021 r. poz. 2150),
- regulation of the Minister of Infrastructure of 26 August 2022 on the technical conditions for tracks for the emergency off-loading of damaged railway wagons transporting dangerous goods (Dz. U. z 2022 r. poz. 1892).

During the process of preparation and execution of the transport of dangerous goods, the Polish Armed Forces base their actions on the guidelines contained in the branch doctrine of the Transport and Military Traffic Subsystem. In the content of doctrine document DU-4.4.1(B) version 2 - principles of transportation of troops by rail transport, such issues can be found:

- general regulations governing military transports,
- principles of the process of planning military transports with the use of railways and necessary documents applicable in this process; competences and tasks of military units and carriers involved in the planning of military transports; railway stations, transport facilities and wagons used during the movement of military equipment,
- organisation of the process of loading, unloading and the entire transport operation,
- regulatory framework for dangerous goods and oversized cargo transport,
- guidelines for safe attachment of various cargoes.

The document also contains a number of annexes, which are elements that expand on the content described above, enabling the essence of the use of rail transport in the context of transporting a variety of cargo and military equipment to be known and understood.

IV. PROCEDURES FOR CALCULATING THE COST OF TRANSPORTING DANGEROUS GOODS

In the literature, the concept of cost is defined as the value of the consumption of physical resources, capital and human labour, expressed in monetary units, necessary to achieve specific economic objectives of an entity. A cost is an economic reflection of expenditures incurred in connection with the conduct of production, service or operating activities, and its incurrence is aimed at obtaining future economic effects in the form of revenues or profits (Szymonik, 2013).

In relation to military transport, the concept of cost should be considered in a broader, functional context, not necessarily related to the pursuit of profit, as is the case in commercial activities. In an armed forces environment, transport costs are not recognised as elements of the profit and loss account, but as necessary financial, material and organisational expenditures incurred to ensure operational readiness, the performance of logistical tasks and the support of combat operations.

The procedures for calculating the cost of transporting dangerous goods by rail involve several fundamental steps, aimed at accurately determining the total cost of transport and ensuring compliance with the applicable standards and regulations. The process begins with a detailed analysis of the characteristics of the cargo to be transported and its physical and chemical properties, which are then compared with the technical parameters of the available wagon types. This analysis takes into account international regulations, in particular the regulations for the international carriage of dangerous goods by rail (RID), as well as national guidelines for the transport of dangerous goods.

The next stage is to select the type and number of wagons adapted to the specific characteristics of the load to be transported. Once the train composition has been determined, technical calculations are made, including the length of the wagons including buffers and the number of calculation axles, which form the basis for further cost analyses.

The next step is to carefully plan the route and determine the transport time based on the individual timetable, which allows the transport schedule to be effectively adapted to the current infrastructure and operational conditions on the route. The final phase of the procedure moves on to calculating the total cost of carriage, taking into account all the rules contained in the document - Framework Agreement No. 53/12/5/2021. The current agreement, which came into force on 2 March 2021, sets out in detail the rules for charging, taking into account the specifics of the cargo transported, as well as its nature and transport requirements. Table 1 below shows the rates of the domestic and international transport services provided.

TABLE. 1. RATES FOR DOMESTIC AND INTERNATIONAL TRANSPORT SERVICES

DOMESTIC TRANSPORT			
Kind of service	Minimum number of calculation axles for transport	Fee for covering one kilometre of the route by one axle of the wagon used [PLN]	
		Own wagons	Wagons owned by PKP Cargo S.A.
Cargo (basic rate)	60	12,18	14,34
Dangerous cargo	60	19,48	22,19
Extremely heavy cargo	60	20,10	23,64
Cargo exceeding loading gauge	60	23,64	23,64
Dangerous cargo unusually heavy or exceeding the loading gauge	60	32,16	37,86
INTERNATIONAL TRANSPORT			
Cargo (basic rate)	60	37,36	43,94
Dangerous cargo	60	59,83	70,36
Extremely heavy cargo	60	61,68	72,53
Cargo exceeding loading gauge	60	61,68	72,53
Dangerous cargo unusually heavy or exceeding the loading gauge	60	98,65	116,08

Source: Own elaboration based on: Framework agreement no. 53/12/5/2021 for the provision of rail transport services concluded on 2 March 2021 in Warsaw.

When determining the total cost of transporting the selected load by rail, an algorithm is used to take into account the key parameters affecting the final cost of the service. The calculation formula is shown in the equation below:

$$A \; x \; B \; x \; C = D \qquad (1)$$

Where:

A – rate appropriate to the load transported [PLN];
B – distance covered [kilometres];
C – number of calculation axles of wagons used;
D – total cost for transporting the selected load by rail [PLN].

The total costs of transporting the selected load by rail will be calculated on the basis of the rate specified in the Framework Agreement, depending on the type of load transported, the actual number of kilometres covered and the number of calculation axles of the wagons used in the train set. It should be noted that the minimum number of axles recognised for billing purposes is 60, which means that even for trainsets with fewer axles, the charge will be calculated as for 60 axles. Additionally, the prices of transport services vary depending on the range (national or international) and are dependent on the ownership of the wagons (PKP Cargo S.A. wagons or those of the ordering party) and the type of freight transported.

V. CASE STUDY ON THE TRANSPORT OF LIQUID FUEL BY RAIL

In order to analyse the costs of transporting military dangerous goods by rail, it was assumed that this would be carried out as a supply transport.

The subject of this chapter is a detailed analysis of the transport of hazardous cargo using rail transport in Poland. The case study is an attempt to practically apply the previously described theoretical, legal and economic issues to a specific logistic operation. The analysis considers the complete transport process - from the preparation of the carriage, through its execution, to the assessment of costs.

A. Characteristics of the dangerous cargo carried

Unleaded petrol 95 is classified as a Class 3 hazardous material under the RID regulations - as a flammable liquid. It is characterised by high flammability, a low flash point and the possibility of toxic vapour emissions, making it a substance that requires special precautions during transport. In the case in question, the total quantity transported was 1,000 m³. The substance was classified under UN 1203, with hazard code 33 (flammable liquid, highly flammable), according to the RID guidelines.

B. Type and preparation of means of transport (railway wagons)

During a thorough study of the physical and chemical parameters of unleaded petrol 95, in juxtaposition with the characteristics of the selected wagons and taking into account any legal regulations, it was determined that a Zaes-type tank wagon would be used to transport this cargo. This is a four-axle wagon, specially adapted for the transport of liquid products, with the tank supported on saddles and secured by steel ties. The Zaes wagon is equipped with a steam heating system and a safety valve, further enhancing its functionality and operational safety. Filling is carried out via the top opening, while emptying is facilitated by drain valves located on both sides. The detailed technical parameters of this wagon, which will form the basis for further analysis, are shown in Table 2.

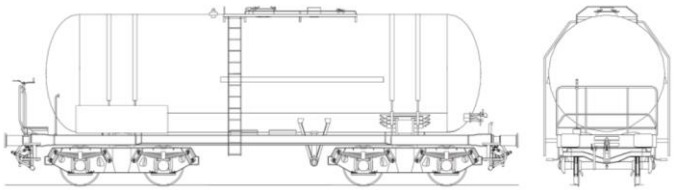
TABLE. 2. THE SELECTED RAILWAY WAGON FOR THE TRANSPORT OF DANGEROUS GOODS

Technical specifications		Type of railway wagon
		Zaes
Specifics of the wagon	-	Railway wagon-tanker
Number of calculation axes	-	4
Weight	[kg]	22 800
Load limit	[t]	57
Loading capacity	[m³]	60

Source: Own elaboration based on: DU-4.4.1(B) version 2, Rules for the transportation of troops by rail transport, Ministry of Defence, Inspectorate of Armed Forces Support, Bydgoszcz 2022, pp.133-134.

Figure 4 below shows the wagon chosen for the transport of dangerous goods

FIGURE 4. TECHNICAL DRAWING OF A ZAES TANKER WAGON



Source: PKP Cargo S.A. wagon catalogue.

FIGURE 5. MILITARY TRANSPORT ROUTE BY RAIL SUWAŁKI - WĘGLINIEC

Source: Own elaboration based on: System Konstrukcji Rozkładu Jazdy. Available online: https://skrj.plksa.pl/kalkulacja.

The means of transport were owned by the carrier - PKP Cargo S.A., which means that operating costs and availability of wagons were settled internally, without the need to lease them from third parties. Prior to the carriage, the wagons underwent a mandatory technical inspection and were provided with the relevant markings in accordance with RID and the safety instructions for the transport of hazardous materials.

C. Transport route and delivery time

The transport was carried out on the Suwałki - Węgliniec route, which was 893 km long. The route ran on railway lines of national importance, partly double-tracked and electrified,

allowing dangerous goods trains to pass in accordance with the procedures in force. Figure 5 below shows the route of the military transport carried out.

Figure 4 below shows the wagon chosen for the transport of dangerous goods

The distances between individual train stations were determined on the basis of individual timetables. The distance was calculated as the sum of the distances between the individual stations at which the train stopped. This value is crucial in terms of determining transport costs. In order to analyse the total transport time, this logistical process was divided into five main stages.

The first stage involved moving the empty wagons to the loading area. Due to safety requirements and the specialised infrastructure needed for liquid fuels, the loading of the petrol did not take place directly in Suwałki, but at a specially adapted fuel terminal some 4 kilometres away from the wagon depot. In the first stage, the railway tanker wagon - owned by the carrier PKP Cargo S.A. - were moved from the staging area to the loading site. This short section, carried out on the basis of an agreed shunting schedule, took 16 minutes. This stage also included the technical preparation of the wagons - including their tightness check, RID-compliant marking and confirmation of technical cleanliness before the cargo was accepted.

The second stage was the loading of unleaded 95 petrol. The loading of the hazardous cargo took place at an adapted distribution point with all safety procedures in place, including grounding of the tankers, temperature control, fuel vapour control and supervision by RID-trained personnel. Due to the amount of cargo (1,000 m³), the refuelling operation of several tankers lasted 3 hours and 20 minutes. After the loading was completed, a final check was carried out to verify the compliance of the transport documentation with the actual technical condition of the depot.

The third stage is the transport from the point of loading to the point of unloading. This is an essential part of the whole operation. The journey time has been estimated on the basis of standard freight traffic, taking into account the speed limits for the carriage of hazardous materials, which are lower than for standard goods trains for safety reasons. Technical stops for formation of the depot, technical inspections of rolling stock and pressure equipment, shunting at sidings and operational stoppages due to traffic management have been added to the total journey time. The need for special stations authorised to handle trains with dangerous goods was also taken into account. The total completion time for this phase was 46 hours and 10 minutes.

The fourth stage was the unloading of the fuel at the destination terminal. The unloading of the petrol was carried out in the secure zone of the fuel terminal in the area of Węgliniec. This stage required preparation of the receiving infrastructure, grounding of the tankers, fire supervision, as well as the presence of services responsible for quality control of the transported fuel. The process of emptying the tankers and completing the transport formalities took 3 hours and 5 minutes. Particular attention was paid to securing the environment against fuel leakage and neutralising the vapour.

The fifth stage was the movement of the empty wagons to the cleaning area or further dislocation. Once the unloading operation was completed, the empty railway tanker wagons were directed to the cleaning area or the next transport task. Due to the need to thoroughly clean the wagons of residual fuel, the tankers first moved 4 kilometres to the technical station, where the initial safety operations were carried out. As in the first stage, the journey time was 16 minutes.

As a result, the total time of the hazardous material transport operation, from the positioning of the empty wagons to their further movement after unloading, was exactly 53 hours and 7 minutes.

D. Calculation of transport costs

The next stage of the analysis was to calculate the freight costs. First, a calculation was made of the number of rail tank wagons with a maximum capacity of 60 m³ that would be required to transport a load of 1600 m³ of unleaded 95 petrol. This calculation will determine the number of rolling stock units required, which forms the basis for further cost analyses. The product of the cargo volume and tanker capacity indicates that exactly 16.67 tankers are required, but as the number of tankers must be integer, we round up to 17. This number of tankers allows the assumed volume of petrol to be transported in full. Once the number of tank cars required has been determined, further parameters such as the length of the wagons including buffers and the number of calculation axles can be determined precisely on the basis of the data contained in doctrine DU-4.4.1(B) version 2. The data collected below is shown in Table 3.

TABLE. 3. TECHNICAL CHARACTERISTICS OF THE SELECTED WAGON

Type of railway wagon	Type of cargo transported	Number of railway wagons used	Length of railway wagons with buffers[metres]	Number of calculations axes
Zaes wagon	Unleaded petrol 95	17	209,78	68

Source: Own elaboration based on: PKP Cargo S.A. wagon catalogue .

Once the number of wagons used has been determined, the next step can be taken, which is to determine the appropriate tariff rates, in accordance with the provisions of the applicable Framework Agreement for the carriage of hazardous cargo. As a result, the adopted unit rate for the carriage of unleaded petrol 95 was set at 22.19 PLN.

In order to carry out a detailed cost calculation, it is necessary to collect and systematise all input data. A summary of this information is presented in Table 4 below, which is the starting point for further calculations.

TABLE 4. INPUT DATA FOR COST CALCULATION FOR TRANSPORTING DANGEROUS GOODS BY RAIL

Input data for transport cost calculation	
Type and quantity of cargo carried	Unleaded petrol 95 – 1000 m3
Type and number of railway wagons used	Zaes railway wagon – 17 units
Transport route	Suwałki-Węgliniec - 893 km
Total transport time	53 hours 7 minutes
Ownership of wagons	PKP Cargo S.A.
Rate for the carriage of unleaded petrol 95	22,19 PLN

Source: Own elaboration.

On the basis of the data collected, it is possible to proceed to the actual calculation of the freight cost. According to the

previously presented algorithm, the total cost for transporting a selected load by rail is calculated as the product of three key variables: the rate assigned to the type of transported load [A], the length of the transport route expressed in kilometres [B] and the number of calculation axles per the used rolling stock [C]. This method of calculation provides a reliable estimate of the cost of carrying out the transport of a hazardous material, in this case unleaded petrol 95.

$$22{,}19 \; x \; 893 \; x \; 68 = 1\,347\,465{,}56 \qquad (1)$$

Where:

A – rate appropriate to the load transported [PLN];

B – distance covered [km];

C – number of calculation axles of wagons used;

D – total cost for transporting the selected load by rail [PLN].

After performing these calculations, it was estimated that the total cost of transporting the dangerous cargo by rail [D] on this particular route is 1,347,465.56 PLN.

The cost of transporting 1,000 m³ of liquid fuel over a distance of 893 kilometres using rail transport was more than 1.3 million PLN. Such an amount can be considered relatively high, especially when compared to the unit costs applying civilian tariff rates, which are usually lower. The difference is mainly due to the specificity and additional requirements of the military for the transport of hazardous materials, such as fuels. In the case of transports carried out for the armed forces, additional operational parameters are crucial - the military expects the precise delivery of a precisely defined quantity of fuel, within a well-defined time frame. This means that there is no possibility to split the transport into smaller batches or to respond flexibly to contingencies, as is often the case in civilian transport. In the civil sector, certain compromises are acceptable, such as delivery delays, splitting transports or flexible schedules - thus optimising costs.

It should also be noted that the aforementioned calculations were for the transport of petrol, but similar costs and constraints arise when transporting other types of military assets, especially heavy equipment. An example is tracked vehicles, which often exceed the dimensions of the loading gauge. This means that such equipment extends beyond the outline of the rail platform. The transport then entails additional logistical difficulties - such a train set has to move according to a customised timetable and there is no possibility of passing other trains on a particular section of the route. This generates additional costs and requires close coordination with the railway infrastructure manager. All of these factors add significantly to the cost of transport for military purposes, which must be taken into account when planning and financing this type of logistical operation.

VI. Conclusions

The aim of the article was to present and analyse the economic and legal aspects of the use of rail transport for the carriage of dangerous goods, with particular emphasis on its use in military transport. Based on the structure of the article, including both theoretical background, analysis of legislation, costing procedures and a case study of fuel transport, it should be stated that the stated objective has been fully achieved. Key terms such as transport, transport system, transport process, military transport and hazardous cargo have been defined, which has made it possible to organise the terminological basis necessary for further analyses. This enabled the topic to be properly embedded in a scientific and practical context. It was confirmed that the transport of dangerous goods by rail - especially in military terms - is subject to a complex legal regime, both nationally and internationally. An analysis of the regulations in force made it possible to identify the most important legal acts and the conditions that must be met for such transport to be carried out in accordance with the safety standards in force. The issue of costs in transport was characterised and a methodology for their determination was presented. The application of this knowledge in practice is shown in the final chapter, where the various stages of transporting a dangerous cargo (unleaded petrol) by rail are described in detail, a logistical analysis is carried out and costs are calculated according to the adopted algorithm. The research problems posed were solved in the course of the subsequent stages of analysis. The article provides coherent theoretical and practical knowledge, which can be a useful source for those involved in military transport logistics, as well as for civilian entities carrying out transport of hazardous materials in the railway system.

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