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Infrastructure Barriers in the Handling of Oversized and Heavy Cargoes, as Exemplified by the Port of Gdańsk

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Andrzej S. Grzelakowski[1], Sławomir Skiba[2]

Abstract:

Purpose: *Identification of infrastructure barriers in the Port of Gdańsk that affect its ability to efficiently handle oversized and heavy cargo, as well as indicating the directions and possibilities of their limitation and rapid elimination in the nearest future.*
Methodology: *A few research methods and techniques were applied: critical literature review, factor analysis, comparative analysis and case study.*
Findings: *Despite its strategic location and development ambitions, the Port of Gdańsk still faces numerous barriers that may limit its competitiveness in the handling of project and special cargo. Therefore, it seems necessary to implement a coherent infrastructure modernization policy, supplemented by increased availability of equipment resources and streamlined planning and operational coordination procedures.*
Practical implications: *A key factor that may negatively affect the scope and capabilities of handling oversized cargo in seaports are the numerous barriers that may be encountered when handling this type of cargo. Awareness of existing barriers can reduce their impact and positively influence the scope of measures taken to limit their impact. In addition, this problem is especially important now from an economic and strategic point of view, as the port infrastructure is an integral component of the country's critical infrastructure. Its quality and technical standards are therefore crucial for the efficient handling of not only the category of cargo that is the subject of the analysis, but also oversized and dangerous cargo sent through the port for military and defense purposes.*
Originality: *This study is an attempt not only to identify barriers limiting the handling of selected cargoes in the Baltic universal ports, using the example of the seaport in Gdańsk, but also indicates existing weaknesses, deficiencies and shortcomings in the critical infrastructure system of such transport hubs of particular importance not only for the economy but also for the country's defense, as is the case here.*

Keywords: *Oversized cargo, port infrastructure, critical infrastructur, infrastructure barriers.*

JEL classification: *R42, L92, O33.*

Paper type: *Research paper.*

[1]*Gdynia Maritime University, Faculty of Management & Quality Science, Gdynia, Poland, ORCID ID: 0000-0001-7190-6115, e-mail: a.grzelakowski@wznj.umg.edu.pl*
[2]*Gdynia Maritime University, Faculty of Management & Quality Science, Gdynia, Poland, ORCID ID: 0000-0001-5832-185X, s.skiba@wznj.umg.edu.pl*

1. Introduction

The infrastructure of the Port of Gdańsk, one of the largest ports in the Baltic Sea basin, is a key element for the development of the economy and maritime trade at regional, national and international level. An analysis of infrastructure barriers in this port, universal in its numerous functions, is essential to identify and resolve any issues that may affect the efficiency and competitiveness of this transport hub, which is strategic for the Polish economy. It is important that the infrastructure is adapted to the requirements of today's transport market, while remaining consistent with the principles of sustainable development and environmental protection and not limiting possible future development.

In the context of the analysis, the infrastructure barriers of the Port of Gdańsk become a key aspect that affects the efficiency and competitiveness of this important transport hub.

The aim of the article is to attempt to identify the infrastructure barriers present in the Port of Gdańsk that affect its ability to efficiently handle oversized and heavy cargo, as well as indicating the directions and possibilities of their limitation and rapid elimination in the nearest future.

Technical limitations (e.g., load capacity and length of quays, lack of appropriate lifting equipment), organizational limitations (e.g., coordination of activities of multiple entities) and spatial limitations (e.g., availability of storage yards, condition of access infrastructure) were analysed. On this basis, critical infrastructure barriers affecting the operational efficiency of the Port of Gdańsk were identified and possible directions for their elimination or reduction were proposed.

2. Infrastructure and Oversized Cargo

The transport of oversized cargo is one of the most demanding tasks in logistics and transport engineering (Lasota *et al.,* 2022). Due to their unusual dimensions, heavy weight and often non-standard shape, the transport of such cargoes involves a number of technical, organisational and formal challenges (Lu *et al.,* 2022). It is crucial to properly prepare the means of transport and the route, as well as to adapt infrastructure elements, including roads, bridges, terminals and port quays (Konovalova *et al.,* 2023; Lozova *et al.,* 2024).

When discussing oversized cargo transport, it is first necessary to clarify the concept of ‘cargo’, which refers not only to road transport, but to all modes of transport (Macioszek 2019). One of the basic definitions describes cargo as ‘a material good, raw material, material, semi-finished product or finished product, moved in the supply chain between the producer (sender) and the consumer (recipient) of the goods’ (Fertach, 2006). The term ‘cargo’ in the literature on the subject is also understood as "goods intended for sale and in the process of being moved, from the moment they are

sent by the sender, i.e. accepted for transport, until they are received by the recipient. It should be borne in mind that not every good is cargo, but every cargo is a good. (Jałowiec 2011; Juściński 2023; Petru *et al.,* 2021).

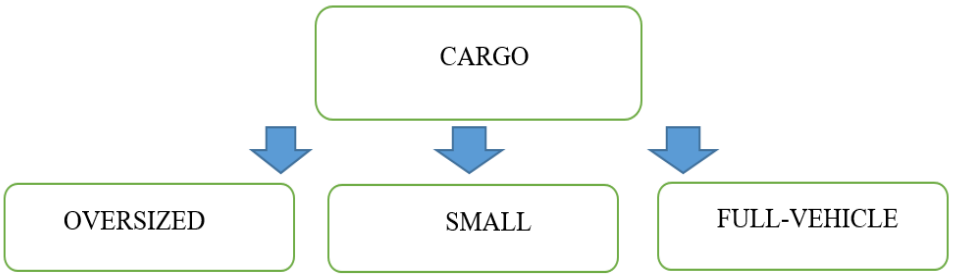
Cargo classification is a process aimed at assigning different goods to appropriate categories (Zhang *et al.,* 2024). In road, rail, sea and air transport, it plays an important role in ensuring transport safety and the efficient organisation of the entire logistics process.

The basic criteria for cargo classification include, among others (Fertach, 2008):

- natural transportability,
- technical transportability,
- basic loading methods,
- cargo size,
- cargo weight and volume,
- economic transportability.

Figure 1 shows a schematic breakdown of loads according to their size, with oversized loads highlighted.

Figure 1. *Division of loads by size criterion*



Source: *M. Fertach. Podstawy logistyki, ILiM, Poznań 2008.*

Barcik states that 'oversized loads, also known as non-standard loads, are loads whose transport requires the use of special means of transport and handling equipment' (Barcik, 2015). The author also presents a classification of oversized cargo based on its dimensions, weight and shape. On this basis, six groups of oversized cargo can be distinguished (Barcik, 2015):

- Oversized standard – these usually include steel structures, small machines and industrial equipment. In addition, work machines and small tanks can also

be mentioned. The weight of these loads does not exceed 25 tonnes. Their dimensions slightly exceed the standards permitted for road and rail transport. These loads are between 15 and 16 metres long, 3.5 to 4 metres wide and 3.0 to 3.5 metres high. It is worth mentioning that these loads do not require specialised semi-trailers for transport. They are usually transported in standard wagons equipped with appropriate devices for marking and securing them.

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- Heavy cargo – this usually includes machinery and equipment for construction and road building. It includes boilers, various tanks and specialised housings for power plant equipment. Other examples of heavy loads include ship components, railway and tram carriages, and complete production lines for the metallurgical and automotive industries. They are characterised by their high weight, ranging from 70 to 100 tonnes.

- Heavy, bulky cargo – these are specific types of cargo, as their weight can reach up to 200/300 tons. They are dominated by power equipment such as transformers, generators, and turbines. These also include parts of bridge and port structures, locks, and ship embankments. Due to the fact that the transshipment of this type of cargo could adversely affect the condition of the roads, special multi-axle road vehicles must be used, which, thanks to the hydraulic suspension, distribute the weight of the cargo in an appropriate way so as not to damage the road (Januła *et al.,* 2011).

- Heavy oversized cargo – this is cargo with a large mass and non-standard dimensions, which requires special means of transport, organisation and procedures. Heavy oversized cargo includes: pipes for pipeline construction, industrial machinery (engines, turbogenerators, industrial furnaces), building structures (bridge elements, wind towers, large precast concrete elements), aircraft, ship and boat parts, as well as turbines and other power equipment. The weight of these loads can be as high as 900 tonnes, and their height can reach up to 40 metres. Such loads can only be transported in their entirety by sea, and sometimes by inland waterways.

- Long loads – typical for the construction industry. These include various types of spans, pillars and crane components. These loads are also in demand in the chemical and petrochemical industries. The length of long loads can exceed 50 meters.

Overcoming these infrastructure barriers requires careful route planning, close cooperation with local authorities, and adapting selected sections of infrastructure to the specific nature of oversized cargo transport. For this reason, such transport requires detailed logistical preparation and obtaining a number of necessary permits.

It should be noted that despite many simplifications, documentation for oversized transport is still relatively complicated and its preparation can be labour-intensive (Januła *et al.,* 2011; Malaksiano 2020). The legal system has detailed regulations on the transport of oversized loads, covering various modes of transport: road, rail, water, air and sea. These rules stem from numerous legal acts aimed at ensuring transport safety, protecting infrastructure and ensuring the efficient organisation of transport.

In the case of road transport, the applicable regulations primarily concern the technical conditions of vehicles, procedures for obtaining permits, and rules for organising journeys for vehicles exceeding the permissible weight and size standards.

These requirements specify, among other things, issues related to piloting, route planning, road tolls and infrastructure conditions for non-standard vehicle combinations. In addition, implementing acts regulating the technical equipment of vehicles and the administrative obligations of carriers play an important role. Local regulations issued by the competent road administration authorities are also important, particularly in the context of agreeing on routes or adapting road sections.

The transport of oversized cargo by rail is subject to separate rules, covering both technical and organisational requirements. These apply, for example, to shipments which, due to their nature, may cause difficulties in the transport and scheduled movement of other trains in operation.

The inland waterway transport sector is governed by shipping regulations and internal regulations issued by the authorities responsible for waterway management. Their purpose is to ensure safe navigation and proper use of waterway infrastructure.

Air and sea transport also have their own separate legal bases. In these cases, regulations focus on safety issues, civil liability and requirements for special cargo.

Regulations relating to the transport of dangerous goods constitute a separate category, providing for special procedures and formal requirements, including the obligation to obtain appropriate permits. In the case of road transport, regulations concerning travel conditions, risk assessment and the need to ensure appropriate security measures are particularly important.

In summary, transport infrastructure plays a key role in the context of oversized cargo transport, both in technical and legal terms (Grzelakowski, 2022). The unusual parameters of such cargo – significant weight, length, width or height – mean that it can only be transported using specially adapted means of transport and carefully planned routes, taking into account the limitations resulting from the condition and design of the infrastructure.

Oversized transport requires the use of specialized vehicles, often modular, with increased load capacity and the ability to adapt to the dimensions of the cargo being transported. It is equally important to adapt individual elements of infrastructure, such as bridges, viaducts, roundabouts, tunnels and quays, to the technical requirements of a specific logistics operation. Failure to make the necessary adjustments can lead not only to traffic disruptions, but also to threats to the safety and durability of the infrastructure (Marek 2018; Melnyk *et al.,* 2020).

A key aspect of transport planning is to take into account the applicable legal regulations. The European Union countries have a comprehensive system of regulations, including laws, executive regulations and local acts, which govern the conditions for the organisation and implementation of oversized transport (Petraška *et al.,* 2017; Onyshchenko *et al.,* 2021).

Their purpose is not only to ensure the safety of road users, but also to protect existing infrastructure from overload and damage. Therefore, the effective implementation of oversized transport requires an integrated approach combining technical knowledge, knowledge of regulations and cooperation with infrastructure management institutions. Only then is it possible to ensure the efficient, lawful and safe movement of loads with non-standard dimensions and weights (Wornalkiewicz *et al.,* 2021; Melnyk 2019).

3. Infrastructure Barriers in Handling Oversized and Heavy Cargo at the Port of Gdańsk: Case Study

In order to achieve the adopted research goals, there were analysed data on several transhipment operations involving oversized and heavy cargo carried out between 2023 and 2025. These operations concerned real projects carried out at the Port of Gdańsk. The analysis was carried out using source documents and interviews with representatives of Gdańsk Port Authority as well as leading stevedoring companies and investors carrying out these orders.

An analysis of logistics operations involving oversized and heavy cargo handled at the Port of Gdańsk has identified specific infrastructure barriers that have a significant impact on the efficiency, safety and costs of handling oversized and heavy cargo.

Firstly, the limited operational availability of quays remains a significant barrier. As a universal port, the Port of Gdańsk often handles bulk carriers, container ships,

military vessels and specialised vessels simultaneously. In practice, this causes congestion and a lack of free berths for special projects. An example of this is a situation where military vessels and bulk carriers occupied quays originally planned for handling heavy cargo. Such an operational collision results in the need for a quick response and reorganisation of the entire loading plan.

Another significant limitation is the lack of permanent access to specialised port equipment. Handling oversized cargo requires the use of hydraulic systems, SPMT self-propelled platforms, skidding systems, and floating and mobile cranes with high lifting capacity. This type of equipment is not available at the Port of Gdańsk, but is provided by external private operators. This prolongs the preparation process, generates the need for additional coordination and affects the level of costs.

The third barrier concerns the port's internal infrastructure, including the road layout and access between quays. Even relatively short cargo relocation between two terminals may require complex logistics, e.g., due to excessively narrow port gates, limited vertical clearance (e.g., viaducts, flyovers) and collisions with urban infrastructure, such as tram traction networks.

The fourth problem is the lack of up-to-date technical documentation concerning the load-bearing capacity of quays, yards and hidden infrastructure, especially in the oldest parts of the inner harbour. Despite the actual use of these areas, they are often not documented in a way that allows for quick planning of operations. Operators must therefore carry out their own geotechnical and geodetic surveys, which unnecessarily complicates and prolongs decision-making processes.

The last, but equally important barrier is bureaucratic procedures. Obtaining permits for non-standard journeys, temporary street closures, power cuts in the traction network or the preparation of alternative routes requires cooperation with many institutions, which significantly prolongs the process. The lack of a uniform system for coordinating such activities in the port region is a challenge that must be taken into account when planning the development of the Port of Gdańsk.

In summary, the Port of Gdańsk has the potential to handle heavy and oversized cargo, but the utilisation of this potential is limited by numerous infrastructural and organizational barriers. In light of the above information, it seems reasonable to introduce modernization programs, transparent access to technical documentation and the development of equipment and logistics facilities within the port.

4. Final Conclusions and Recommendations

The aim of the article was to identify infrastructure barriers limiting the capacity of the Port of Gdańsk to handle oversized and heavy cargo, and at the same time, indicate the directions and possibilities of their limitation and rapid elimination in the nearest future.

The analysis of the literature on the subject and the applicable procedures was supplemented with case studies of actual logistics operations carried out at the port in recent years. This made it possible not only to identify formal and technical limitations, but also to highlight the practical challenges associated with the planning and implementation of complex transhipment operations. During the analysis, five main problem areas were identified:

- limited availability of operational quays,
- shortage of specialised port equipment,
- insufficient internal infrastructure,
- lack of up-to-date technical documentation,
- burdensome administrative procedures.

Each of these aspects can significantly affect the course and efficiency of cargo handling operations requiring an individual approach due to their size and weight, increasing their cost, lead time and operational risk. Both the case study and the analysis of conclusions drawn from the operational documentation indicate that, despite its strategic location and development ambitions, the Port of Gdańsk still faces barriers that may limit its competitiveness in handling project and special cargo.

It seems, therefore, to be necessary to implement a coherent infrastructure retrofitting policy, supplemented by increasing the availability of equipment resources and streamlining planning and operational coordination procedures. In particular, it is worth emphasising the need to standardize and update the technical documentation of quays and to provide real support for operators planning non-standard transshipments.

This is the only way to improve the functioning of the port as a logistics and transport hub as well as a facility of particular strategic importance for the economy that meets all the criteria for logistics and transport efficiency, while maintaining the required standards in the development of critical infrastructure and, as a component of the network industry system, the ability to generate synergy effects on a national and European scale (Grzelakowski, 2022).

Otherwise, all already existing weaknesses, deficiencies and shortcomings in the port critical infrastructure of particular importance not only for the economy but also for the country's and regional defense system, could lower the standards required to build its competitive position at the Baltic port services market and in the global logistics market, making it a not fully functional and reliable component of both national defense as well as economic systems.

References:

Barcik, R. 2015. Uwarunkowania transportu ładunków ponadgabarytowych transportem samochodowym. Logistyka.

Fertach, M. (red.). 2006. Słownik terminologii logistycznej. IliM, Poznań.

Fertach, M. (red.) 2008. Podstawy logistyki. ILiM, Poznań.

Grzelakowski, A.S. 2022. Global strategic maritime infrastructure and its impact on shipping industry and supply chains management. Proceedings of the 39th International Business Information Management Association Conference (IBIMA) 30-31 May, Granada, Spain.

Jałowiec, T. (red.) 2011. Towaroznawstwo dla logistyki. Wybrane problemy. Difin, Warszawa.

Januła, E., Truś T., Gutowska, Ż. 2011. Spedycja. Difin, Warszawa.

Juściński, S. 2023. Comprehensive analysis of oversized cargo transportation market in Poland (2001-2022): Trends, regulations, and industry dynamics. Journal of Sustainable Development of Transport and Logistics, 8(2), 136-152.

Konovalova, T.V., Senin, I.S., Nadiryan, S.L., Kotenkova, I.N. 2023. Application of Logistics Methods in the Organization of Transportation of Oversized Cargo. Transportation and Information Technologies in Russia, 13(2), 47-59.

Lasota, M., Jacyna, M., Wasiak, M., Zabielska, A. 2022. The Use of Multi-criteria Methods in the Problem of Selecting Vehicles for Oversize Cargo Transport. In: Scientific and Technical Conference Transport Systems Theory and Practice (pp. 22-47). Cham: Springer International Publishing.

Lozova, G.M., Klymenko, V.V., Dzherdzh, Y., Yeroshenko, O.R. 2024. Economic Aspects of Organizing the Delivery of Oversized Cargo by Transport Enterprises in Ukraine. Економічний Вісник Державного Вищого Навчального Закладу Український Державний Хіміко-Технологічний Університет Учредители: Украинский государственный химико-технологический университет, 20(2), 115-124.

Lu, W., Choi, S.B., Yeo, G.T. 2022. Resilient route selection of oversized cargo transport: the case of South Korea–Kazakhstan. The International Journal of Logistics Management, 33(2), 410-430.

Macioszek, E. 2019. Conditions of oversize cargo transport. Zeszyty Naukowe. Transport/Politechnika Śląska, (102), 109-117.

Malaksiano, M.O., Melnyk, O.M. 2020. Vessel selection prospects and suitability assessment for oversized cargo transportation. Scientific Notes of Taurida National VI Vernadsky University. Series: Technical Sciences, 31(70), 1.

Marek, R. 2018. The analyses of the Polish marine container terminal market based on porter's model of five competitive forces. International Conference on Traffic and Transport Engineering. Proceedings.

Melnyk, O. 2019. Safety Issues of Oversized Cargoes Transportaion by Sea: Array. Municipal economy of cities. Series: Information Technology and Engineering, 6(152), 204-208.

Melnyk, O., Malaksiano, M. 2020. Effectiveness assessment of non-specialized vessel acquisition and operation projects, considering their suitability for oversized cargo transportation. Transactions on maritime science, 9(01), 23-34.

Onyshchenko, S., Shibaev, O., Melnyk, O. 2021. Assessment of potential negative impact of the system of factors on the ship's operational condition during transportation of oversized and heavy cargoes. Transactions on maritime science, 10(01), 126-134.

Petru, J., Krivda, V. 2021. The transport of oversized cargoes from the perspective of sustainable transport infrastructure in cities. Sustainability, 13(10), 5524.

Petraška, A., Čižiūnienė, K., Jarašūnienė, A., Maruschak, P., Prentkovskis, O. 2017. Algorithm for the assessment of heavyweight and oversize cargo transportation routes. Journal of Business Economics and Management, 18(6), 1098-1114.

Skiba, S. 2017. Analiza procesu obsługi intermodalnych jednostek kontenerowych w Bałtyckim Terminalu Kontenerowym. Gospodarka Materiałowa i Logistyka. 2017(12 (CD).

Skiba, S. 2020. Outsourcing as a method of recruitment in the tsl sector. Economic and social development: Book of proceedings, 339-344.

Skiba, S. 2013. Model ewidencji kosztów logistyki. Logistyka, 6.

Wornalkiewicz, W., Kravchyk, Y., Kaplunovska, A. 2021. The oversized cargo forwarding: economic and legal aspects.

Zhang, B., Huang, J., Su, Y., Wang, X., Chen, Y.H., Yang, D., Zhong, Z. 2024. Safety-Guaranteed oversized cargo cooperative transportation with closed-form collision-free trajectory generation and tracking control. IEEE Transactions on Intelligent Transportation Systems.