The Concept of Intermodal Shipment Terminal as a Complement of Transport Logistic Network for the Wrocław Agglomeration

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Wroclaw agglomeration is presented in the structure of the national and international transport system as well as directions of development of basic transport modes in Wroclaw. The situation of intermodal transport in Poland against the background of Europe and other countries was presented. Attention was drawn to the technical and technological problems of existing intermodal transport terminals in the Wroclaw agglomeration. The economic premises of the International Logistic Centre in Wrocław and the concepts of the Centre's construction are discussed. The PKP PLK Wroclaw Osobowice station was proposed as the location of the Logistic Centre, whose main technological element is the intermodal transport terminal.

Keywords: Intermodal Shipment Terminal, intermodal transport, International Logistic Centre in Wrocław.

1. THE WROCŁAW AGGLOMERATION IN THE STRUCTURE OF THE NATIONAL AND INTERNATIONAL TRANSPORT SYSTEM

The scale of business activity in Poland (which is a derivative of EU accession in recent years) and the growing importance of interregional and international cooperation generate the need for new quality services [8]. The long-standing practice of Western European countries indicates that modern logistics centres, including transport logistics centres, can guarantee that quality. The construction of these centres seems to be necessary in quite large urban, industrial and port urban areas (with more than half a million inhabitants) and in areas of a thriving cross-border community. The location of such facilities should be based on the analysis of multimodal terminals' ability to provide free access to international transport arteries (motorways, railways with transhipment facilities, waterways and airports).

The article discusses the main directions of Wroclaw's transport system development on the basis of four components: the circular road network, the waterway, the airport and the railway junction. Wroclaw was described as one of the most important regions qualifying for the location of an international logistic centre. Two versions of the concept of the Wroclaw International Logistics Centre (WMCL) were presented at the 7th Polish-Dutch Forum [8]. Attention was focused on the location of the Centre in the area directly adjacent to the Wrocław-Poznań railway (E59), in the area of PKP station Wroclaw Osobowice and Wrocław Świniary. Suggestions for Terminal Infrastructures, adapted to various Combined Transport Systems, were considered, and the possibility of adapting a typical container station according to the UIC Guidelines was considered.

2. THE WROCŁAW AGGLOMERATION IN THE STRUCTURE OF THE NATIONAL AND INTERNATIONAL TRANSPORT SYSTEM

West European railways and other continental trains indicate that intermodal transport is the most efficient way to take advantage of the different modes of transport [7]. Progress in land transport in Europe has been the result of the enlargement of the European Union by 12 new states. On the other hand, the liberalization of the railway market, which is characteristic for the EU countries, has led to an increase in the intermodal transport system (which is a positive tendency, among others

in the aspect of environmental protection). The phenomenon of increasing the scale of transport in the intermodal system forces the search for universal solutions, which improve the transport technology. One such example is the introduction of European Integrated Load Units, which are containers fitted with collapsible components [7].

In 1970, the International Union of Combined Rail Road Transport Companies (UIRR) was established to support combined transport in Europe [7]. It connects intermodal transport operators mainly engaged in road and rail transport. Currently, the UIRR controls the movement of more than 70% of rail transport related to intermodal transport in Europe. UIRR members are operators of more than 260 terminals located in several European countries (also in Poland). Container handling is dominant as it is implemented in approximately 98% of UIRR terminals, interchangeable bodies and semi-trailers in 86% terminals, while Rollende Landstrasse is operated only in 4% terminals [7].

In Western Europe, despite the developed network of highways, the share of combined services in general rail transport is approximately 15%. In Switzerland, LGV transit in over 80% is carried out by combined transport. In the Nordic transport corridor north-south (Sweden, Norway, Finland, Denmark, Germany, Austria, Switzerland, Italy), combined transport carries almost 50% of all cargo. The "intermodal" leading countries have long-term development plans, there are specially established teams monitoring the transport system. Due to the anticipated growth in Europe, it is expected that appropriate operational measures should be expected. For example, in Switzerland [7]:

- the speed of freight trains is increasing, in order to compensate for the difference in speed with respect to passenger trains,
- the capacity of trains increases by increasing the composition of intermodal trains to at least 750 m,
- piggyback swing trains on the route from north to south are introduced.

3. THE SITUATION OF INTERMODAL TRANSPORT IN POLAND

The proportions of the state of implementation of the intermodal technology in Poland in relation to the rest of the world are as follows: in the USA 50% of freight is intermodal, 60% in Switzerland, in Germany, Italy and the UK. Britain - 30%, in Poland only 3.5% (including transport of about 2% of cargo).

The campaign for intermodal transport carried out by the Institute of Citizenship calls for, inter alia, the following:

- systemic changes as a derivative of proper transport policy (on railway infrastructure in absolute values Poland allocates less funds from the Czech Republic, while on roads 1.5 times more)
- increase the amount of money spent on railways and introduce the "polluter pays" principle.

Barriers to the development of intermodal transport include: Technical condition of railways, low quality of rail services (e.g. relatively long transport time), price competitiveness of combined transport (e.g. high freight prices), insufficient number of logistics transport centres. Access to Polish roads is one of the cheaper ones in Europe, while the tracks are more expensive.

Specialists see the possibility of developing an "intermodal" in Poland, giving a realistic scenario for the system's share in freight traffic of 10% by 2020. The increasing trend in intermodal rail transport is indicated by data from the Railway Institute [3] on the share of intermodal transport by rail:

- according to the transported mass of cargo 0.94% in 2003 and 3.48% in 2012,
- according to the transport work done 1.71% in 2003 and 6.21% in 2012.

The number of transported intermodal units (TEU) transported by rail was about 234 thousand in 2003, while in 2012 over 1 million.

Transportation of containers is the dominant technology of intermodal transport in Poland. Their share in all transported units, eg in 2011, was 97.9%. On the other hand, there are no or only occasional transports (on railway platforms) of semitrailer tractors with trailers and with the driver of a truck. The container terminal network in Poland was shown according to 2008 data [7] in figure 1. In contrast, data from 2013 indicate the functioning of approximately 30 intermodal terminals [3]. On these facilities, mainly reloading of containers is carried out, in smaller numbers - interchangeable bodies and whole road sets. The largest number of terminals is located in Poznań (6), Katowice (5), Warsaw (3), Wroclaw (3) and in seaports [3, 7]. The number of terminals is not in line with Western standards, which means that

there should be approximately 40 container terminals in Poland with stationary cranes, warehouses and rail sidings with a total length of more than 600 m (excluding mobile reloading equipment, which must be reached in emergency situations).

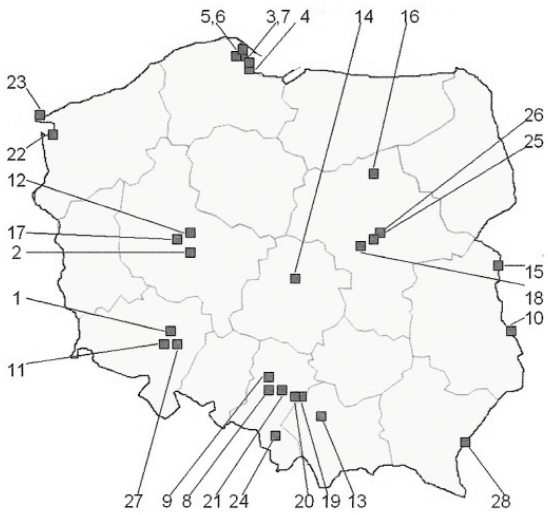

Fig. 1. The position of the intermodal terminal in Poland [7]:
1-Brzeg Dolny, 11 – Kąty Wrocławskie,
27 – Wrocław (main).

The development of intermodal transport is supported by actions, focusing around the Operational Program Infrastructure and Environment (OPI & E), under Priority VII Environmentally-friendly Transport, Measure 7.4 [3]. Financial support is received, among others. Projects for the construction of new terminals (e.g. the next two in the Poznan agglomeration) and modernization or expansion of existing ones (e.g. Brzeg Dolny and Kąty Wrocławskie in the agglomeration of Wroclaw).

In the paper [3], in addition to information on current projects to improve the state of the infrastructure for intermodal transport in Poland, directions for support to 2020, according to the Program [13], are given. The support program [13] in its introduction diagnose the existing state of the intermodal and makes the following observations:

– deficiencies in the equipment of terminals for loading equipment, insufficient number of tracks, track length less than the required minimum 650 m to handle the trains of intermodal trains,
– the need to modernize railway line and point infrastructure used in intermodal transport systems.

The OPI & E Program [3, 13] also provides for the possibility to purchase or upgrade traction vehicles and specialized rolling stock (e.g. wagons). The anticipated effect of the OPI & E Program will be to increase the speed of intermodal trains to 100-120 km / h on main transport routes in Poland, between terminals and main border crossing points. In article [3], attention has been paid to the need to improve the competitiveness of intermodal rail transport, emphasizing that the above mentioned maximum trains will enable competitive trades (in the transport chain between the sender and the customer) to reach 50-60 km / h. At present, the road transport speed is 40-60 km / h, with a maximum speed of 90 km / h. On the other hand, the transport speed of intermodal rail freight, according to the Transport Authority for 2012 [UTK], is below 30 km / h. One of the main causes of this problem is the unsatisfactory technical condition of the linear infrastructure [3].

4. THE EXISTING INTERMODAL TRANSPORT TERMINALS IN THE WROCŁAW AGGLOMERATION

There are three container terminals in the Wroclaw agglomeration area: Wroclaw (Polzug Intermodal), Brzeg Dolny (PCC Rail Containers) and Kąty Wrocławskie (Schavemaker) [7].

The Wrocław terminal [7] is located at the siding of the Wrocław-Główny railway station. Access to the car is possible via the national road No. 94 (Wroclaw-Opole) and the bypass of the city centre. The terminal layout is connected to the E30 railway and located near the freight yard of the PKP PLK Wroclaw Brochów station. Equipment and technical specifications of the terminal (terminal area and storage area, loading fronts, cargo lanes, TEU capacities and others) are given in monograph [7]. The disadvantage of the infrastructure is the length of the tracks (2 tracks 300 m long and one 180 m long), shorter than the required EU guidelines.

The Brzeg Dolny terminal [7] operates on the premises of PCC Rokita S.A. Equipment (reloading equipment, terminal area and storage area, TEU capacity) and technology are discussed in [7]. Only one short (100 m) transshipment front attracts attention.

The Katy Wroclawskie Terminal [7] was launched in 2006 and is currently being modernized under the OPI & E Program [9]. The technical parameters (including a loading front

consisting of two tracks of the total length of 640 m) and the existing condition for 2008 are presented in monograph [7]. In contrast, article [9] discusses the faults of the existing state and selected problems of modernization, which is a necessity, to adapt the track system at the terminal to the general requirements. These problems of planned modernization are due, inter alia, to [9]:

– limited terminal area, which results in the lack of possibility to obtain tracks with the recommended minimum guidelines of 600 m,
– complex shape of the terminal parcel (informal polygon), which makes it difficult to design the lines in a straight line over their entire utility length,
– restrictions on the direction and location of the siding to the terminal area.

Due to the increasing tendency of intermodal transport in the total volume of freight transport by rail, there is a need to increase the number of existing terminals, their size and to expand the scope of logistics services. This problem is also related to the agglomeration of Wroclaw, as evidenced by the content of the reports, developed at the beginning of the 21st century by competent institutions such as the Government Centre for Strategic Studies, Wrocław Regional Development Office, Wroclaw Infrastructure Office, Wroclaw Development Office [8].

5. THE DIRECTIONS FOR THE DEVELOPMENT OF THE WROCŁAW TRANSPORT SYSTEM

Vehicle Roads

The improvement in freight transport by Wroclaw is the result of the Wroclaw Motorway Ring Road (2011), the Bypass Road (2010-2011) and the "Gądowianka" Viaduct, which connects Grabiszyn with Gądow Mały. On the other hand, road bridges that have existed for several decades are not fully adapted to the transport of goods due to technical parameters and location as well as existing access routes in a densely built street area. Other barriers, which are difficult to cross the street, include railway junction lines, irrigated fields, protected aquifers, and industrial complexes.

Waterways

Oder waterway has the potential to serve as the main inland waterway in Poland. Through the Odra-Havel and Odra-Sprewa canals, there is a connection to the waterway system of Western Europe. Odrzańskie ports can act as transshipment hubs in case of development of intermodal transport. There is a forecast for the Odra up to 2025, taking into account the realization of the Danube-Odra investment by this time [14]. It is expected that a significant impact on the development of shipping on the Oder will be to trade goods with Western European countries, which will force not only the increase of bulk cargo transport but also the increase in container and RO-RO transportation. Wroclaw's Popowice port is located within a short distance from the station of the Wroclaw Osobowice Railway Station and Wroclaw Świniary. The area of these PKP stations is considered in this article as a variant of the organization and construction of Wroclaw Integrated Logistics Centre.

Wrocław Railway Node

As it is known, Wroclaw Railway Node is located on international transport routes, covered by AGC and AGTC agreements. Each of these agreements lists the European transport lines of international importance, including the lines planned for modernization, in order to increase the speed of operation of qualified trains and to improve the quality of the transport services provided and the lines provided for construction. The linear and station infrastructure of Wroclaw Node is currently being modernized [10].

The construction of the logistic centre at the PKP Wrocław Osobowice station was justified by the Railways District Railway Authority (PKP) in Wrocław in 1998 [5], taking into account:

– approximation to the planned railway bypass north of Wrocław junction (this investment has not commenced to date),
– convenient connection to Wroclaw river port and airport,
– location of PKP Wroclaw Osobowice station within E59 Wrocław-Poznań.

6. THE CONCEPT OF THE INTERNATIONAL LOGISTIC CENTRE IN WROCŁAW

Wroclaw's location in the transport corridors of south-western Poland is a significant determinant of the accelerated economic growth and transformation of the region, stimulated by the process of integration with Western Europe. Wrocław agglomeration is becoming an important

centre of distribution, logistics and warehousing. It is characterized by assets to take the initiative to create a large multicentre logistic centre or an integrated centre, operating on the principle of locating the group quite close to each other located sub-centres. These sub-centres are already partially functioning and are connected by a section of the Wrocław Motorway Ring Road [8, 14].

An analysis of the currently upgraded transport network (road and rail) in Wroclaw's agglomeration allows to generate the following three concepts of construction and location of the logistic centre in Wroclaw.

1. The city area of 200-250 ha, located in the area directly adjacent to the E59 railway line, on the section of PKP Wroclaw Osobowice and Wroclaw Świniary (Figure 2). The infrastructure of this facility would meet European standards.
2. South-West of Wroclaw, a zone of economic activity. In this zone there is the Lower Silesian Agricultural and Food Wholesale Centre which, as one of the largest such facilities in the country, can generate demand for transport services. It is possible to consider two locations:
   – the western edge of the Muchobór Wielki district, between the Wroclaw Bypass and the Wrocław Airport boundary,
   – the area of the railway station Wrocław Żerniki, covering the area adjacent to the south to the railway E30 Zgorzelec-Wroclaw, with coverage from the current areas in Żerniki to business facilities in Złotniki.
3. The concept of logistics sub-centres, consisting in the use of an existing group of integrated logistics sub-centres, located in the immediate or close vicinity of the Motorway bypass of Wrocław. This group should have an information and management centre with a main cargo pickup terminal and international logistics services. Other objects of the group would include:
   – an intermodal transshipment terminal at the PKP node in Muchobor, after its adaptation to such functions,
   – CARGO terminal at Wroclaw Airport, connected to Wrocław Motorway bypass,
   – Lower Silesian Centre of Agricultural and Food Wholesale, connected with the Motorway Ring Road of Wroclaw,
   – freight forwarding and distribution companies located in the "functional belt" of Wrocław Motorway bypass and Port of River in Popowice.

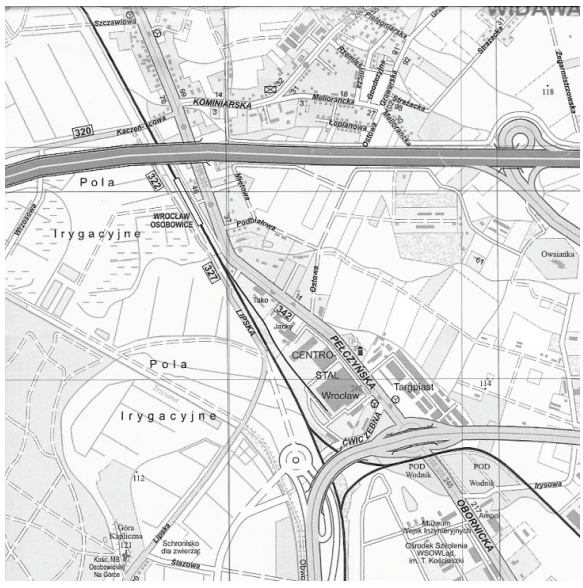

Fig. 2. Situation plan of a fragment of the area of Wroclaw,
Along the railway line E59, on the section of PKP Wrocław Osobowice station [12].

7. THE AREA OF THE PKP PLK STATION WROCŁAW OSOBOWICE AS THE LOCATION FOR THE LOGISTIC CENTRE

General Remarks

The rational location of Wroclaw Integrated Logistics Centre from the point of view of solutions in railway infrastructure seems to be an area adjacent to the area of PKP Wrocław Osobowice station. The strategic location of this facility is also apparent from the nearby and capable of cooperation with the Centre for Road Infrastructure [8, 14]:

– National Road No. 342 of Wrocław-Oborniki Śląskie, directly connected to the expressway S5, leading in Poznan,
– Wroclaw Motorway Ring Road, to which entry is possible at the Widawa junction,
– Downtown Wroclaw Ring Road, which connects the area of the centre by the adjacent to the railway station PKP Wroclaw Osobowice Street Pełczyńska (national road No. 342).

Attention should also be paid to the close location of the International Airport Wrocław Strachowice CARGO, which is currently being communicated with the area of PKP Wroclaw

Osobowice station via the Wroclaw Motorway bypass, via the "Widawa" and "Airport" junctions. The significance of the E59 railway bus on which the PKP station is situated is also important. It is a route connecting the area of the considered Logistic Centre with the Wroclaw Railway Node.

Basic technical and operational parameters

E59 bus and track circuit of PKP station Wroclaw Osobowice.

On the E59 bus, where the PKP station is situated, the maximum speed of 160 km / h, cargo 120 km / h and the permissible axle load of 221 kN are applicable. Ultimately, the technical and operational parameters of the route will be adapted to AGC and AGTC contract provisions [14].

E59 bus tracks and PKP train tracks are 60E1 type rails, SB3 rails are fastened to the sleepers. Station turnouts with characteristics: 60E1 - R = 300 m, R = 300 m, 1: 9 and 60E1 - R = 1200 m, slope 1: 18.5 [14].

The Design Concept for the Combined Transport Terminal

It was proposed to locate the terminal on the western side of the PKP station, within the existing irrigation fields, whose liquidation was declared in recent years by the Wrocław City Council. For this purpose, a special track should be built at the station, branching from the existing secondary track (where the platform is located) and connecting the PKP station with the terminal track layout. The terminal would consist of two main objects (which could be arranged in series along a two track railway line):

1) container station (SK),
2) groups of trains handling combined transport (GT-PTK).

In view of the qualification of the E59 bus to the international category, a typical container station with the symbol Est2 was adopted for use in the UIC catalogue (Figure 3) [4]. The main elements of the container station infrastructure (SK) include:

– track system: group of arrival and departure tracks, lift track (designed for manoeuvring wagons), group of cargo lanes, take-off and cleaning tracks;
– transshipment and work vehicles [7] (gantry crane, gantry crane on wheels, self-propelled telescopic forklift, reach-stacker, mast with side shanks, mast with gripper, Container truck with front forks;
– transshipment and transport infrastructure: loading road and transshipment yard;
– service objects.

There are at least one track to handle only containers (transloads using spreaders). The special wagons or so-called container wagons will be substituted for this track. European wagons of container platform (total length of platform with bumpers Lc = 18,170 m [6]).

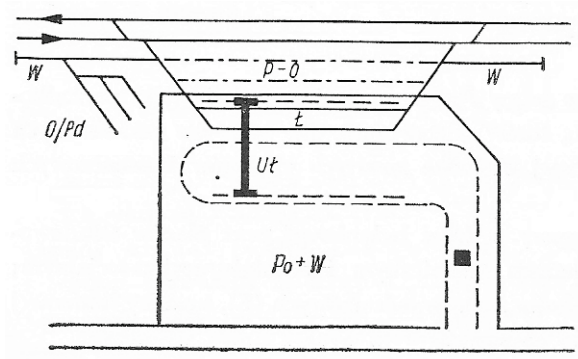

Fig. 3. Model diagram of a typical container station with the symbol Est2,
According to the UIC catalogue [4]: P-O - W - lift track, Ł - group of tracks, O / Pd - Uł - load infrastructure (gantry crane, reloading truck, access road and transshipment yard), Po + W - yard and service facilities.

In the group of GT-PTKs, which, due to the provision of interoperability, should be connected via a communication path to the Est2 container station, the following logistics infrastructure is proposed.

1. Sector for the operation of a train composed of special wagons with rotary low platform, defined by the PWAT symbol (wagon design was developed by the Military Technical Academy team [1]). According to the authors of the publication [1], the construction of the wagon enables quick and easy autonomous loading, transport and autonomous unloading of TIR trucks, without investing in the development of additional infrastructure (e.g. construction of a special platform for loaded and unloaded vehicles). The platform is composed of a fixed part connected via a frame with two-axle bogies and a rotating part. The direct entry of the tractor with the semi-trailer onto the platform and the departure is possible on the basis of the movement of the moving part (in the process of loading and unloading) within ± 45o.

Sector for PWAT includes the following elements [1]:
- specialized track (pass or "ribs", or "blind"),
- access road (two way),
- roundabout (unidirectional)
- two manoeuvring areas (top layer of 0.27 m thick, made of cement concrete, reinforced concrete),
- two manoeuvring roads (one way) at the squares.

In order to enable the tractor to run smoothly onto the platform and descent, the manoeuvring pavement surface should rise to a height of 0.185 m in relation to the rail head level. The surface of the manoeuvring yard in the immediate vicinity of the track (on which the PWAT platforms are located) should be reinforced on both sides at a width of 2.50 m. The authors [1] propose reinforcement with 2.5 m wide steel plates (dimension perpendicular to the axis of the track) The length of 3.0 m, which is the top layer (so-called) pavement. The horizontal distance of the square curb from the axis of the transshipment line was assumed to be 1.60 m, according to the design guidelines for the railway sector's cargo facilities.

The work [1] presents two technological variants of the PWAT loading and unloading operations, for loading and unloading of one platform and ten platforms.

The logistic transshipment solution with a special platform (according to the patent [1]) is adaptable on the premises of the proposed Osobowice terminal, without having to make investments that generate significant costs.

2. Track for the operation of low-roll wagons, according to Rollende-Landstrasse [2, 6, 7]. Wagons are characterized by a lowered floor length (depending on the wagon type, height 410-450 mm above the railhead head, for the 602S platform type: 600 mm), used for the transport of trucks, road sets (car + trailer) or road vehicles Combination kits (tractor + semitrailer). After the use of special support beams, these wagons can also be used to transport semi-trailers alone. Reduced drag-and-drop devices in these wagons allow vehicles to pass from the wagon to the wagon. Terminal wagons are equipped with front mounted drag-and-pull devices to enable the whole group to be included in any classic train composition.

Polish representative of low-floor railway platforms in the Ro-La transport system is a 602S platform gantry, manufactured by TABOR SZYNOWY OPOLE S.A. [15]. Entrance to the platform of the transported vehicles is carried out on a self propelled basis, using an open-toped ramp provided to the first wagon, which also serves to link the platform with a locomotive and other (typical) wagons. The vehicle exit of the platform is identical. In the case of loading operations of vehicles on platforms and unloading, no specific terminal construction and equipment is required. Only two factors are relevant:
- access to the ramp,
- properly cured substrate between railway tracks (eg asphalt concrete, cement concrete, prefabricated concrete slabs), to allow the truck to enter the railway platforms and exit.

The 602S platform is characterized by the following key parameters [15]:
- gauge wagon UIC 505-1,
- length of the wagon with swing-arms with deviating deviations: 20400 mm, length of load 18260 mm,
- loading width (in the tire area) 2520-2620 mm,
- payload of 44 t (+ 10%),
- max axial load 9.75 t,
- minimum horizontal radius required in track R = 150 m,
- max speed of operation 100 km / h.

3. Track for handling of semi-trailers, semitrailers and large containers transported on special container and pocket wagons (Huckepack system, piggyback). It is recommended to perform transshipment above the specified intermodal transport unit (JTI) using [2,6]:
- Lifts fitted with jaws gripping JTI grip on its base, either
- Equipped with a universal spreader with tweezers.

4. Load track for operating the bimodal system [2, 6]. The system consists in the transportation of semitrailers on special wheelchairs equipped with adapters. Adapters allow direct coupling of the semi-trailer with the cart. The lifts in which the semi-trailer is fitted are sufficient to form a bimodal train composed of semi-trailers. Lifters allow vertical displacement of the semitrailer and the axles of the rear wheels. The operation can be performed on a terminal equipped only with a manoeuvring platform for road vehicles, which is a cured and levelled plate at the height of the

railhead. It should also be possible to operate the train carriages after deformation of train composition. Only one person - truck driver - is required to carry out the operation of the trailer on or off the train.

8. CONCLUSIONS

The theme of the article - in the absence of details - demonstrates the nature of the design concept and is the first stage of the project, carried out by the authors. The next step will be the elaboration of technical solutions in the infrastructure of both facilities (SK container station and GT-PTK combined transport operator) to form the terminal. It should be emphasized that the impact of the proposed Logistics Centre and the integrated Centre for Combined Transport Terminal would cover a much larger area than the city of Wroclaw, given the location of these rail sites, covered by the AGC and AGTC contracts, and close to international road routes.

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