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INTRODUCTION

We are giving readers another publication created as a result of the discourse of scientists and practitioners conducted as part of the TranSopot conference, concerning the research and challenges of transport development in the 21st century. TranSopot Conference 2018: "Challenges for transport development in the 21st century" was held on 27th–29th May at the Faculty of Economics of the University of Gdańsk. The goals of the meetings as part of the conference are based on the exchange of opinions on the main challenges and discussion of current directions of transport development. Another important aspect of the conference is the integration of scientists and practitioners in the field of transport and the publication of research results and discussion of new research areas. This paper contains 26 articles sent to this year's conference, addressing a wide spectrum of current problems and challenges concerning transport, both research and operational. The issues raised in the published articles focus on the characteristics of the current state of transport, innovation in particular modes of transport, competition, infrastructure, management, efficiency and operation of transport companies.

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Editor of the volume

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MANAGEMENT MODEL OF RAILWAY STATIONS WITH THE FOCUS ON SUSTAINABLE DEVELOPMENT OF PUBLIC TRANSPORT

Abstract

The article presents the assumptions of a modern management model of railway stations. In this model, the station is perceived as part of a multimodal hub which includes, besides the building used for passenger' check-in, also railway platforms, access routes and surrounding infrastructure in the form of public transport stops and parking lots and other facilities. The authors point to the necessity of constructing interchange nodes integrating the station with the urban tissue. The article discusses the issue of categorizing stations and standardizing services at railway stations to best meet the needs of users. The authors point out that innovative solutions are the key condition for improving the quality of stations. The station design process should be linked to the current review and the search for innovations in the field of materials, energy, ICT, architecture and passenger services. An interesting direction for the development of railway stations are services related to the sharing economy, such as co-working, car-sharing and bike-sharing. The article also presents the concept of creating an integrated entity managing the passenger station area, a model of solutions in other European countries.

Keywords: railway stations, interchange nodes, multimodal hubs, categorization, standard of passenger services, innovations, sharing economy, integrated management

Introduction

Changing mobility trends pose new challenges for railway stations. Individual motorization is developing dynamically, as well as forms of collective transport

that are competitive to rail – bus and air connections. In the years 2000–2016, the number of cars per 1.000 inhabitants in Poland increased from 261 to 564, i.e. by 116%[1]. The number of air transport passengers on domestic routes increased from 875.000 people in 2010 to 1.3 million people in 2016[2], i.e. by more than 50%, while one of the leading long-distance bus carriers within 65 months of the start of operations carried 20 million passengers[3].

There is also an increase in alternative forms of movement, e.g. shared journeys, car rental systems and city bikes. All these phenomena mean that maintaining the attractiveness of the railway requires continuous improvement of the quality of services at railway stations and closer integration of the station with the surroundings. The railway station should encourage the use of public transport, providing the necessary comfort and enabling efficient change between modes of transport.

1. The station as a multimodal hub

Conducted by the Polish State Railways (PKP S.A.) in 2014 survey of railway station users[4] illustrates the perception of railway stations by passengers. The survey showed that under the slogan "railway station" the most commonly used is a transfer node connected with urban transport and long-distance bus transport. The visible border of the station is only public road. In general, Polish State Railways is responsible for the image of the entire area, including cash registers, ticket machines (regardless of the operators serving them), and even commercial services provided at the station.

The total travel time from the place of departure to the destination is, apart from the price, one of the most important criteria for choosing a way of moving. A private passenger car has a natural advantage over collective transport, allowing for a direct passage from door to door. From the point of view of the total travel time, the functionality of the station, as a transfer point between various modes of transport and the potential "moderator" of travel, significantly affects the attractiveness of the entire logistic collective transport chain. Travel by train requires the use of at least two passenger stations, which is why the quality of transfer points can be a decisive factor in the choice of rail transport relative to the individual. The railway station should, as far as possible, eliminate the inconvenience of transferring, that is minimize the time and passenger effort devoted to this activity. The answer is the construction of communication and interchange centers (multimodal hubs) enabling a quick, convenient and economically justified change, ensuring comfort and safety, as well as providing additional services.

A correctly designed interchange node ensures the integration of the railway station with collective transport (tram, bus) and individual. The optimal location

[1] *Rocznik statystyczny Rzeczypospolitej Polskiej 2017*, Central Statistical Office, Warsaw 2017, p. 66–67.
[2] *Ibidem*, p. 545.
[3] Public Transport Portal, http://www.transport-publiczny.pl/wiadomosci/polski-bus-od-startu-przewiozl-20-mln-pasazerow-53504.html (access: 20.02.2018).
[4] *Jakościowe badanie eksploracyjne użytkowników dworców*, Millward Brown, Warsaw 2014.

of stops, as well as park & ride, kiss & ride and bicycle parkings located near the station are important. A desirable solution is to create nodes with priority for pedestrian traffic, so that they are safe and comfortable to use. The determinant of this priority is, for example, the lack of barriers in the form of streets, which pedestrian must pass on the way from the station to the public transport stop. Station forecourts should become, in principle, zones of safe pedestrian traffic and limited or excluded car traffic, which are mainly accessible to public transport vehicles. An additional element that increases the level of integration of means of public transport may be a common passenger information system, allowing, for example, access to urban transport timetables at the railway station.

An important component of the standard resulting from legal regulations is also the implementation of the TSI PRM standards on the accessibility of rail for the disabled and with reduced mobility[5]. The solutions used at railway station buildings should correspond to the concept of universal design, which according to the definition is to serve as many users as possible, without the need for additional improvements[6]. Due to the binding legal regulations, as well as the image of infrastructure managers, PKP and PKP PLK work together to ensure proper access to passenger station facilities (including stations), services and information for everybody, both disabled and not having mobility restrictions.

An example of the implementation of a modern interchange is Marburg in Hesse (Germany) – a city of 70 000 inhabitants, which was chosen the German Railway Station of the Year 2015 in the Allianz pro Schiene plebiscite[7]. The station was integrated with the surroundings and allows convenient transfers to buses, as well as access to and leaving the bicycle or car. A restricted traffic zone was created in front of the building with a maximum speed of 20 km/h. The station building itself was fully adapted to the needs of people with reduced mobility by means of ramps, mechanical devices and facilities for the blind.

One of the most important aspects related to the implementation of investments at railway stations is cooperation with external entities that have both indirect and direct impact on their implementation and are their beneficiaries. It is necessary to plan the implementation of the investment taking into account the plans of the national infrastructure manager of PKP PLK, which not only manages rail tracks, but also elements of passenger infrastructure, i.e. platforms and routes to access them. Only this type of cooperation will ensure the elimination of the problem of non-uniform standard in the area of the passenger station. In addition, PKP Group undertakes cooperation with local government units and private entities being the owners of the areas around the station. Its purpose is to extend the scope of works including the construction of integrated transfer nodes, including stops

[5] COMMISSION REGULATION (EU) No 1300/2014 of 18 November 2014 on the technical specifications for interoperability relating to the availability of the Union's rail system for people with disabilities and persons with reduced mobility (L series of journals in the European Union No 356 from 12 December 2014).

[6] *Projektowanie uniwersalne. Ekspertyza w zakresie dostępności kolejowych obiektów obsługi podróżnych z niepełnosprawnościami oraz ograniczoną możliwością poruszania się*, Office of Rail Transport, Warsaw 2017.

[7] Allianz pro Schiene website, https://www.allianz-pro-schiene.de/presse/pressemitteilungen/marburg-und-obstfelderschmiedelichtenhain-sind-sieger/ (access: 20.02.2018).

and parking lots, and the adaptation of the urban fabric, which is the immediate surroundings of the railway station, to new standards and needs of travelers.

2. Categorization and standardization of stations

The survey of railway station users was the starting point for the development and implementation of a new categorization of stations and the related service standard. Introduced by PKP in 2015, the new categorization structure (Premium, Voivodeship, Regional, Agglomeration, Local and Tourist stations) is based on pro-passenger criteria. It replaced the earlier technical categorization (A, B, C, D, E). The new division of stations takes into account the role played by individual objects in passenger transport and takes into account factors such as the location and importance of the communication node, the leading type of railway traffic, users' cross-section, as well as service and social functions. The operating categorization of stations and selected factors determining the assignment to particular categories are shown in Table 1.

Table 1. Categorization of railway stations of PKP

	Premium	Voivodeship	Agglomeration	Regional	Local	Tourist
Location	big city		up to 50 km from the center of a large city	medium or small city	small town or village	a place of tourist importance
Traffic Type	long-distance (high)		agglomeration	long-distance (low), regional		tourist
Communication Node	at the country level	at the intervoivodeship level	at the level of agglomeration	at the voivodeship level	low traffic potential	important seasonally
Station Users	wide range of users and motivation		a permanent group of people (regular commuting, schools – usually a short time at the station)			high tourist traffic (seasonal)
Services, Commercial Functions	maximization of commercial functions, a wide range of services	significant commercial functions, a wide range of services	no significant commercial functions, possible additional services	the lack of important commercial functions is less common, the range of services depends on the location	no significant commercial functions, minimal range of services	special user needs resulting from less time pressure
Other	expectations regarding the social function of the station (meeting place, cultural events)		–	–	–	tourist and cultural functions

Source: own elaboration based on: internal materials of PKP

For each station category, a package of services was defined, i.e. the target standard and a set of services that should be provided on a given site. It is a response to passenger needs that arise from the type of facility and the nature of the traffic. According to the survey results, over 80% of people arrive at the station within 30 minutes before the train departure[8]. However, there are differences between people arriving on a long-distance train and regional or agglomeration; for persons traveling on inter-voivodship trains, the trend of earlier arrival at the station is visible. For this reason, it is assumed that the scope of commercial functions performed by Agglomeration stations will be much lower than in the case of Premium or Voivodeship railway stations servicing significant long-distance traffic. In addition, variants of extending the service catalog within the concept of tailor-made services will be analyzed for each station. In addition to the minimum package of services, the organization will strive to implement commercial services that respond to the current diagnosis of the needs of people using the station in a given location. At the stage of commencement of project works for each station facility, actions are undertaken to diagnose the needs in the area of commercial space. Their diversity should correspond to the real needs of travelers and take into account the rational management of financial resources.

Achieving the target parameters of railway stations requires undertaking actions in the field of innovation, quality and accessibility of services as well as cooperation with external entities. Innovative solutions are a key condition for increasing the quality of stations. The station design process is linked to the ongoing review and search for innovations in the areas of materials, energy, ICT, architecture as well as passenger services. The currently updated catalog of innovative solutions is used in subsequent station projects.

In the course of work carried out by PKP innovations aimed at increasing the operational efficiency of stations are developed. The use of new technologies decreases operating costs and reduces the negative impact of the station building on the environment. One of such innovations is the intelligent Building Management System (BMS), which connects all installations at the station into one unit, allowing efficient and economical management of the entire facility from one place. The BMS controls the work parameters of individual devices, informs about problems and failures and also allows the settlement of media usage. Systematic implementation of other solutions is planned, e.g. the use of rainwater as water for flushing toilets, installation of energy-efficient LED lighting, photovoltaic cells, heat pumps and energy-saving gas furnaces, as well as the creation of green roofs. In place of oversized station buildings, it is envisaged, if local conditions allow, to build smaller, repeatable buildings with one standard of execution, while optimizing the surface.

The paths of obtaining innovative solutions take into account the possibilities of cooperation with units implementing tasks in the area of science, science and technology as well as innovation policy. In connection with the key project of innovative railway stations, PKP joined the work of the European Shift2Rail initiative. As part of the cooperation between PKP will conduct research in the field of "Improved

[8] *Badanie satysfakcji z podróży w pociągach PKP Intercity*, report of the 6th stage of the study, Millward Brown, Warsaw 2015, p. 317.

Station Designs and Components" and "Crowd Management in High Capacity Stations". An important advantage of cooperation is the possibility of preferential use of research results carried out by other organizations participating in Shift2Rail.

In the areas of safety, comfort, ergonomics and IT, innovative activity is focused on acquiring ready-made solutions offered by innovative enterprises. One of the effects of such action was the implementation of an online sign language interpreter at the station's information points, which allows direct contact between the station employee and the person with a hearing impairment. An interesting trend from the point of view of innovative services connected with railway stations is the development of sharing services. Such services include co-working, which means sharing by a few or a dozen small companies one headquarters and work space, in order to reduce the fixed costs of operations. Due to its central location in relation to the city center, the station is an ideal place. Other sharing services include car and bicycle sharing systems, which are an alternative to owning your own car and a complement to public transport.

3. Integrated management of the passenger station area

In order to achieve the target standard of passenger services, the model of integrated management of a passenger station should be adopted. In accordance with the qualitative survey of railway stations earlier referred to, users perceive the station as one unit consisting of a hall, platforms, as well as tunnels, access roads, and parking lots. The present practice of managing stations by PKP Group revealed the imperfections of the adopted model, in which the responsibility for managing the station building, platforms and access routes is divided between the two companies: PKP and PKP PLK. Thanks to the cooperation of the Companies in previous years, selected services (e.g. cleaning) were standardized throughout the passenger area by conducting one proceeding and concluding joint contracts with contractors, however, there are still difficulties in coordinating investment and maintenance work, deepened by unclear responsibilities and duplication of competence.

In order to ensure high-quality passenger services, it is necessary to integrate them throughout the passenger station area, i.e. at the station building, platforms and access routes. The integration of services may take place through the consolidation of functions related to the management of passenger infrastructure (stations buildings, platforms, access routes), held separately until now by the companies of PKP and PKP PLK, as part of a specialized organizational unit that equipped with appropriate tools will be able to make decisions more efficiently and coordinate maintenance and investment works. The details of the functioning of such a structure in Poland, its competences, and the method of financing, require analyzes taking into account local Polish conditions. Organizational solutions involving integrated management of the passenger station are used in other European countries. In Germany, the specialized company DB Station & Service manages the whole area of the passenger station and owns the station buildings. The owner of the platforms and routes of access to them is the railway infrastructure manager DB Netz, and DB

Station & Service manages these elements on his behalf, based on the use agreement (Nutzungsüberlassungsvertrag). A solution similar to the German one is used in France, where maintenance services in the whole passenger railway area are provided by a dedicated SNCF entity under the name SNCF Gares & Connexions, partly commissioned by the SNCF Réseau railway infrastructure manager.

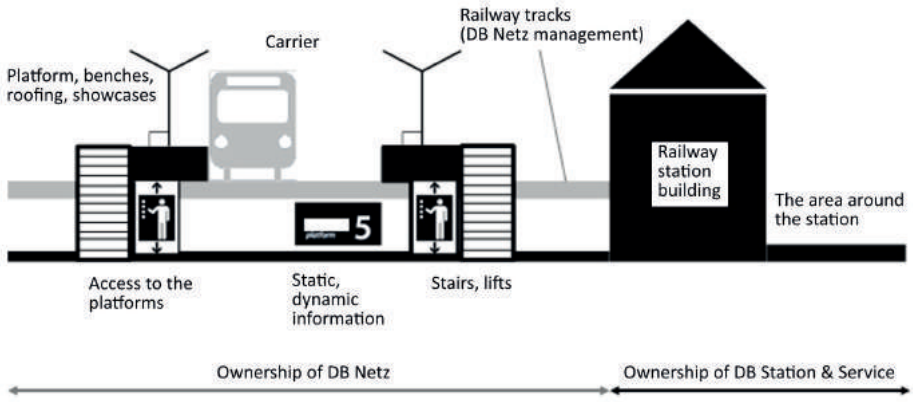

Figure 1. Management of the passenger station and division of ownership in the German model (elements covered by integrated management are marked in black)
Source: own elaboration based on: *We build and operate train stations!*, DB Station & Service AG presentation material, 2015

Integrated management allows planning, execution of investment and operating works, as part of a coherent process throughout the passenger service area. The integration of passenger station management in one hand will bring benefits both from the point of view of the quality of services and tangible cost synergy effects resulting, for example, from concluding one contract for various services and works performed by external companies, such as media supply, purchase of materials, repairs, security services. Potentially easier are also arrangements with external partners (e.g. local government units and external companies) regarding the construction of interchanges and development of facilities. The separation in the structure of PKP Group of the business segment related to passenger service facilities is a tool for more effective management by PKP Group of an area that plays a special social role.

Conclusions

Changing mobility trends, based primarily on individual motoring, enforce the adjustment of railway stations to new requirements. The quality of services at railway stations can be a decisive factor in the selection of collective transport in relation to the individual. It should be noted that the functioning of railway stations serves not only the business objectives of the railway, but also (and

perhaps above all) the implementation of the public mission and transport policy of the state. The effects of actions taken by PKP to improve the quality of service at railway stations, will also be consumed by external entities, including local entrepreneurs (e.g. carriers, trade) and local government units, where the stations are located, as well as the general public, thanks to improved transport accessibility of the locality and reduction of pollution and congestion caused by passenger cars. Station railway investments lead to increased accessibility of public transport for all users, in particular for people with reduced mobility. In order to achieve the target standard of passenger services, an integrated approach to the shaping and operation of interchanges should be adopted, consistent with the common perception of railway stations as a logical whole with platforms, routes to access them and the immediate surroundings. This means ceasing to designate areas of responsibility for the passenger station and its surroundings solely on the basis of the ownership title held. Following the discussed foreign practices, the integration of passenger station management can take the form of a dedicated entity managing the entire travel service area.

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We build and operate train stations!, DB Station & Service AG presentation material, 2015.

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MODELS OF TIME SERIES WITH SEASONAL FLUCTUATIONS IN THE FORECASTING OF PASSENGER TRAFFIC IN AIR TRANSPORT BASED ON THE STUDY OF WROCŁAW AIRPORT

Abstract

Forecasting is one of the measure used in the planning process. It enables effective management of infrastructure and available human resources, including at airports. However, improper prediction of future trends may have economic consequences for the company. Therefore, the aim of the study is to determine forecasts of the number of passengers and air operations characterized by the smallest deviations from the real values, on the example of Wrocław Airport. For the needs of the study, an analysis of econometric models of seasonal fluctuations was carried out, as well as the method of seasonality indicators and homologous period trends. The methods were selected due to the low level of forecast error using expired forecasts for 2017. The study was completed with the choice of a method generating forecasts burdened with the smallest error.

Keywords: econometric models of seasonal fluctuations, seasonal indices, homologous period trend, air transport

Introduction

The efficiency of infrastructure management and disposable human resources in business units is possible, among others thanks to proper forecasting, being one of the elements used in the planning process. Therefore, the aim of the study was to determine forecasts of the number of passengers and air operations characterized by the smallest deviations from the real values, on the example of Wrocław Airport.

Due to the occurrence of seasonal fluctuations, forecasting of passenger traffic in air transport is more complicated than in the case when these fluctuations do

not occur. In addition, it is worth noting that "isolating the impact of seasonal fluctuations on the shaping of the forecasted phenomenon and its inclusion in the forecasting process raises the precision of predictions"[1].

The study analyzed econometric models of seasonal variations, using the seasonality method and the trend of homologous periods. Quarterly data from the years 2012–2017 made available by the Civil Aviation Office and the analyzed airport were used. Based on the indicated methods, forecasts of expired passenger numbers and the number of flight operations for 2017 were made. While verifying the ex post forecast, it was assumed that the obtained level of forecast errors is the justification for expanding it to the next 2018.

1. Methodology

In econometric models of seasonal fluctuations, some dummy variables are introduced, which correspond to the distinguished phases of the cycle. The estimated coefficients located at these variables are therefore measures of cyclical effects[2]. The general record of the model with the linear trend and the periodic seasonal component is as follows[3]:

$$\hat{y} = \alpha_0 + \alpha_1 t + \sum_{k=1}^{m} d_{0k} Q_{kt} + U_t \text{ maintaining the condition: } \sum_{k=1}^{m} d_{0k} = 0,$$

where:
α_0, α_1 – model parameters,
d_{0k} – model parameters reflecting fixed parts of seasonal effects in individual phases of the cycle,
Q_{kt} – a dummy variable taking values equal to 1 in periods/moments corresponding to k-th phase of the cycle and equal to 0 in periods/moments corresponding to other phases of the cycle,
k – variable specifying the number of the seasonal cycle,
U_t – a random component.

In addition to the above, the study uses the method of seasonality indicators[4] and the method of trends of homologous periods[5]. Based on the indicated methods, the process of determining expired forecasts was carried out (the expired

[1] P. Dittmann, *Prognozowanie w przedsiębiorstwie. Metody i ich zastosowanie*, Oficyna Wydawnicza, Cracow 2003, p. 83.
[2] Z. Pawłowski, *Ekonometria*, PWN, Warsaw 1966, p. 161.
[3] *Zastosowanie hierarchicznych modeli szeregów czasowych w prognozowaniu zmiennych ekonomicznych z wahaniami sezonowymi*, ed. J. Zawadzki, Agricultural University of Szczecin Publisher, Szczecin 2003, p. 9–10; P. Dittmann, *Prognozowanie w przedsiębiorstwie...*, p. 129.
[4] Full methodology in: A. Barczak, *Pomiar wahań sezonowych ruchu pasażerskiego na przykładzie Portu Lotniczego Gdańsk*, Folia Pomeranae Universitatis Technologiae Stetinensis. Oeconomica 2015, 321(80)3, p. 5–14.
[5] Full methodology in: A. Barczak, *Metoda trendów jednoimiennych okresów jako narzędzie prognozowania ruchu pasażerskiego na przykładzie Portu Lotniczego Gdańsk* [in:] *Wybrane zagadnienia logistyki stosowanej*, vol. 4, ed. J. Feliks, AGH University of Science and Technology Publisher, Cracow 2016, p. 13–24.

forecast is a forecast that is "determined for the t time, for which the real value of the forecast variable is known"[6]) and subsequently – forecasts for 2018.

2. Forecasting

For all estimated econometric models of seasonal fluctuations and in the case of trends of homologous periods, the type of model was selected based on graphical analysis and the analysis of increments for numerical data on passenger traffic at Wroclaw Airport. The basis for adopting the models for further analysis was to meet the following conditions:

– the determination coefficient in the range (0.5625;1);
– the random variation coefficient not exceeding 15%;
– randomness of the rest of the estimated models (tested using a series test).

First of all, the results obtained using econometric models of seasonal fluctuations were depicted. The model of the time series, taking into account seasonality for the number of passengers, has the form:

$$\hat{y} = 437746.1531 + 11710.2688t - 121837.2844Q_1 + 33084.9469Q_2 + \\ + 153489.9281Q_3 - 64737.5906Q_4,$$

where:
$R^2 = 0.9901$[7],
$Vs = 3.40\%$[8].

Table 1 presents estimated forecasts for 2017 for the number of passengers using the data for 2013–2016 together with forecasting errors[9].

Table 1. Forecasts expired for 2017 using the time series analysis with regard to seasonality for the number of passengers

Period	Forecast	Absolute error forecast ex post	Relative forecast error ex post (%)
I quarter	514 983	42 312	7.59
II quarter	681 616	59 052	7.97
III quarter	813 731	100 668	11.01
IV quarter	607 214	35 495	5.52

Source: own elaboration based on: by Civil Aviation Authority in Poland (http://www.ulc.gov.pl/pl/regulacja-rynku/statystyki-i-analizy-rynku-transportu-lotniczego – access: 20.02.2018) and Airport Wrocław (http://airport.wroclaw.pl/lotnisko/o-lotnisku/statystyki/ – access: 20.02.2018)

[6] M. Cieślak, *Organizacja procesu prognostycznego* [in:] *Prognozowanie gospodarcze. Metody i zastosowania*, ed. *idem*, PWN, Warsaw 1997, p. 56.
[7] Coefficient of determination.
[8] Random variation coefficient.
[9] Full methodology in: A. Barczak, A. Nurzyńska, S. Król, *Transport we współczesnej gospodarce – wybrane aspekty*, Sophia Scientific Publisher, Katowice 2017, p. 49–50.

For the number of air operations, the estimated model of the time series, taking into account seasonality, is:

$$\hat{y} = 4490.9188 + 101.8625t - 621.7063Q_1 + 279.4313Q_2 + 864.3188Q_3 - 522.0438Q_4,$$

where:
$R^2 = 0.8007$,
$Vs = 11.00\%$.

Table 2 presents the forecasts of the number of aviation operations designated for 2017. Data for 2013–2016 were used and ex-post prediction errors were determined.

Table 2. Forecasts expired for 2017 using the time series analysis with regard to seasonality for the number of aviation operations

Period	Forecast	Absolute error forecast ex post	Relative forecast error ex post (%)
I quarter	5601	361	6.06
II quarter	6604	489	6.89
III quarter	7291	819	10.10
IV quarter	6006	565	8.60

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

After assuming that a forecast error of up to 10% of the real value is admitted, the analysis of the absolute error of the ex post forecast and the relative error of the ex post forecast shows that the expired forecasts are characterized by relatively small deviations from the actually observed number of passengers and the number of operations at Wrocław Airport, excluding the third quarter. Therefore, time series models were estimated with regard to seasonality, successively for the number of passengers and flight operations using data for the years 2013–2017:

$$\hat{y} = 418447.125 + 14679.35t - 120797.675Q_1 + 34503.575Q_2 + \\ + 160262.625Q_3 - 73968.525Q_4,$$

where:
$R^2 = 0.9753$,
$Vs = 4.52\%$,

$$\hat{y} = 4309.3656 + 129.7938t - 619.3094Q_1 + 279.4969Q_2 + 902.5031Q_3 - 562.6906Q_4,$$

where:
$R^2 = 0.8664$,
$Vs = 7.93\%$.

On this basis, quarterly forecasts of both variables for 2018 were calculated, excluding the third quarter (Table 3).

Table 3. Forecasts for particular quarters of 2018, including errors[10], using the time series analysis, taking into account seasonality for the number of passengers and flight operations

Period	Forecast	Average prediction error S_T^P	Relative forecast error ex ante η_T (%)
Numer of passesngers			
I quarter	605 916	28 539.5792	4.71
II quarter	775 896	28 925.2667	3.73
IV quarter	696 783	29 783.2600	4.27
Number of air operations			
I quarter	6 416	495.8887	7.73
II quarter	7 444	502.5902	6.75
IV quarter	6 862	517.4983	7.54

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

The analysis of the error of the average prediction and the relative error of the ex ante forecast shows that the estimated forecasts are characterized by small deviations from the actually observed values. The lowest relative prediction error of 3.73% was obtained in the second quarter for the number of passengers, and the highest was 7.73% in the first quarter for the number of air operations.

The second method used is the seasonal factors method. In order to conduct the forecasting process for each variable, empirical data charts were determined. On this basis, it was possible to conclude on the course of seasonal fluctuations. In each case, they were series with occurring periodic fluctuations with an amplitude having a growing character over time which indicates multiplicative properties. Therefore, the function of the exponential trend was determined for quarterly data on the number of passengers served and flight operations. Subsequently, corrective coefficients were determined to change the raw seasonality indicators into cleared ones. Then the values of forecasts expired for 2017 were estimated and ex post forecast errors were determined (Table 4).

Table 4. Forecasts expired for 2017 using the seasonality ratio method for the number of passengers and flight operations

Period	The form of the trend function	Forecast	Absolute error forecast ex post	Relative forecast error ex post (%)
Number of passengers				
I quarter	$\hat{y} = 416503.2206\, e^{0.0268t}$	505 052	52 243	9.37
II quarter		720 867	19 801	2.67
III quarter		892 004	22 395	2.45
IV quarter		623 349	19 360	3.01

[10] Full methodology in: A. Barczak, *Wykorzystanie wybranych metod ilościowych w analizie pasażerskiego ruchu lotniczego w Polsce*, Scientific Papers of University of Economics in Wroclaw, Economics 2015, 401, p. 26–35.

Table 4. cont.

Period	The form of the trend function	Forecast	Absolute error forecast ex post	Relative forecast error ex post (%)
Number of air operations				
I quarter	$\hat{y} = 4498.6281\, e^{0.0190t}$	5 480	–482	8.09
II quarter		6 667	–426	6.00
III quarter		7 496	–614	7.57
IV quarter		5 946	–625	9.51

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

The analysis of the determined seasonality ratios indicates that in the examined period (2013–2016) only due to seasonality the number of passengers in the first quarter was lower compared to the trend by 23.11% on average, in the second quarter higher by 6.84%, third quarter higher by 28.71%, and in the fourth quarter lower by 12.43%. In the case of the number of flight operations, due to seasonality, their number compared to the trend in the first quarter was lower on average by 11.81%, in the second quarter higher by 5.28%, in the third quarter – by 16.14%, while in the fourth quarter, it was lower by 9.61%.

Due to the fact that this method of forecasting is not based on a formal model and it is not possible to determine the forecast error[11] in Table 5, it was limited to presenting the estimated trend functions and forecasts for 2018.

Table 5. Forecasts for individual quarters of 2018 using the seasonality ratio method for the number of passengers and flight operations

Period	The form of the trend function	Forecast
Number of passengers		
I quarter	$\hat{y} = 412017.8542\, e^{0.0283t}$	581 974
II quarter		818 848
III quarter		1 012 904
IV quarter		708 438
Number of air operations		
I quarter	$\hat{y} = 4389.8156\, e^{0.0228t}$	6 292
II quarter		7 617
III quarter		8 596
IV quarter		6 846

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

The analysis of seasonality ratios, using the data for 2013–2017 indicates that in the analyzed period, the number of passengers in the first quarter was lower by 22.04% in the first quarter as compared to the trend, 6.63% higher in the second quarter, in the third quarter it was higher by 28.22%, while in the fourth quarter it was lower by 12.82%. As a result of seasonality, in the case of the number of operations, compared to the trend, their number in the first quarter was lower on average

[11] J. Jóźwiak, J. Podgórski, *Statystyka od podstaw*, PWE, Warsaw 2009, p. 441–442.

by 11.21%, in the second quarter by 5.08%, in the third quarter – by 15.90%, while in the fourth quarter, 9.77% lower.

Another method used for the needs of the study is the method of trends of homologous periods. The estimated trend models for individual quarters, along with the basic adjustment measures are presented in Tables 6–7.

Table 6. Trends of homologous periods for the number of passengers (2012–2016)

Period	The type of trend	The form of the function	R^2	V_s (%)
I quarter	exponential	$\hat{y} = 283395.8606\, e^{0.0978t}$	0.8996	5.65
II quarter	quadratic	$\hat{y} = 644628 - 94740.8571t + 18890.1429\, t^2$	0.7772	5.00
III quarter	linear	$\hat{y} = 587678.2 + 32299.2\, t$	0.9184	2.57
IV quarter	exponential	$\hat{y} = 348362.889\, e^{0.0971\, t}$	0.9669	3.05

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

Table 7. Trends of homologous periods for the number of flight operations (2012–2016)

Period	The type of trend	The form of the function	R^2	V_s (%)
I quarter	quadratic	$\hat{y} = 5211.2 - 783.8857\, t + 155.7143\, t^2$	0.9157	2.88
II quarter	quadratic	$\hat{y} = 8384.4 - 2339.9143\, t + 399.2857 t^2$	0.9735	2.49
III quarter	quadratic	$\hat{y} = 7145.8 - 1150.7429\, t + 231.8571\, t^2$	0.8199	5.00
IV quarter	quadratic	$\hat{y} = 5377.6 - 904.3571\, t + 203.6429\, t^2$	0.8172	7.02

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

Tables 8–9 contain expired forecasts, including errors, for the number of passengers and the number of flight operations, respectively.

Table 8. Forecasts expired for 2017 with the use of trends of the homologous periods for the number of passengers

Period	Forecast	Absolute error forecast ex post	Relative forecast error ex post (%)
I quarter	509 609	47 686	8.56
II quarter	756 228	–15 560	–2.10
III quarter	781 473	132 926	14.54
IV quarter	623 809	18 900	2.94

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

Table 9. Forecasts expired for 2017, including errors, using trends of the homologous periods for the number of operations

Period	Forecast	Absolute error forecast ex post	Relative forecast error ex post (%)
I quarter	6114	–152	–2.55
II quarter	8719	–1626	–22.92
III quarter	8588	–478	–5.89
IV quarter	7283	–712	–10.84

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

Again assuming that a forecast error of up to 10% of the real value is admitted, using the method of the trends of the homologous periods (data for 2013–2017) for the first, second and fourth quarter for the number of passengers and for the first and third quarter for operations was determined regarding the air operations (Table 10). For these periods, the forecast for 2018 was set, as well as the error of the average prediction and the relative error of the ex ante forecast (Table 11).

Table 10. Trends of the homologous periods for the number of passengers and air operations (2013–2017)

Period	The type of trend	The form of the function	R^2	V_S (%)
Number of passengers				
I quarter	exponential	$\hat{y} = 284775.8461\, e^{0.1313t}$	0.9745	3.58
II quarter	exponential	$\hat{y} = 447111.5803\, e^{0.0947t}$	0.9516	4.01
IV quarter	linear	$\hat{y} = 349308.3 + 57107.5t$	0.9852	2.45
Number of air operations				
I quarter	exponential	$\hat{y} = 3757.7368\, e^{0.0828t}$	0.8181	6.90
III quarter	linear	$\hat{y} = 4899.6 + 580t$	0.7806	8.46

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

Table 11. Forecasts for selected quarters of 2018, including errors, using trends of homologous periods for the number of passengers and flight operations

Period	Forecast	Average prediction error S_T^p	Relative forecast error ex ante η_T (%)
Number of passengers			
I quarter	626 095	22273.6138	3.56
II quarter	789 191	34893.7772	4.42
IV quarter	691 953	18516.09	2.68
Number of air operations			
I quarter	6 176	485.9070	7.87
III quarter	8 380	813.6230	9.71

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

Conclusions

In the case of econometric models of seasonal fluctuations, the highest errors of ex post forecasts were obtained in the third quarter. The situation is similar for the forecast of the expired passenger population based on the trends of the homologous periods. In the case of the number of air operations, the highest error was in the second and fourth quarter. It should be emphasized that for expired forecasts generated using the seasonality ratio method, the relative error of the ex post forecast did not exceed the 10% threshold.

Based on the values of relative errors, ex post forecasts can indicate the values forecast for individual quarters of 2018 (Table 12).

Table 12. Forecasts for particular quarters of 2018 for the number of passengers and flight operations – an overview of methods

Period	Number of passengers – forecast	Number of air operations – forecast
I quarter	605 916*	6 176***
II quarter	789 191***	7 617**
III quarter	1 012 904**	8 380***
IV quarter	691 953***	6 862*

* econometric model of seasonal fluctuations, ** seasonal indices method, *** homologous period trend

Source: own elaboration based on: by Civil Aviation Authority in Poland and Airport Wrocław

Summarizing, the analysis of errors of expired forecasts indicates that the most reliable forecasts can be obtained using the trend method of homologous periods.

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PROBLEMS OF EFFECTIVENESS OF IMPLEMENTATION OF THE PUBLIC TRANSPORT INTEGRATION PROCESS AT A REGIONAL LEVEL

Abstract

It is generally established that the integration of collective transport in several counties brings benefits to the passenger as to the price of the service, quality and travel time. The aim of the article is, basing on the premise of the theory of economics and organization, to present the view that the integration process encounters barriers limiting its positive effects. Barriers are on the side of the characteristics of the public transport sector itself, the organization, the tariff-ticket system, and the approach of local government authorities (local politicians) and the role of intellectual capital. The article indicates the difficulties in measuring the effectiveness of the integration process.

Keywords: regional public transport, effectiveness, integration

1. Features of the public transport sector in the urban agglomeration

The public land transport sector consists of carriers (operators) serving rail traction (railways, trams) and bus traction. In railway, tram and bus traction, carriers are mainly municipal or State Treasury. The division of the public transport sector in servicing the urban agglomeration is important due to the risk of business operations and the freedom to find new markets and development expansion.

Municipal enterprises (as internal entities) in the transport service of the urban agglomeration operate on the so-called "closed market". As a result, they are not afraid of competition, they know in advance time (several years) the volume of transport work and the revenues they will receive for its performance. The revenues of these carriers are not dependent on the frequency of passengers and tickets sold. The operator does not need to conduct marketing research. Such a system

of administering municipal operators in the urban agglomeration eliminates business risk and does not induce any innovations in passenger service. Municipal carrier (internal entity) cannot compete on the regional transport market.

The municipal government by means of the organizer determines what tasks each operator should perform, sets the passenger tariffs/prices for a period of 3–5 years, the way of ticket distribution. The local government (owner of the carrier) bears the risk of the amount of the deficit arising between the revenues from the sale of tickets and the payment to the operators. The lack of independence of municipal carriers (internal entities) indicates that the integration of transport in the area of several local governments is dependent only on the political will, knowledge and skills of those administering these local governments.

2. Activities that make up the integration process

The concept of integration is not explicitly defined e.g.: "integration is the extent to which the units of the organization have to cooperate in a coordinated way"[1], or "integration is the merging of elements and creating from them the system, organization". In turn other scientists such as e.g.: P.R. Lawrence, J.W. Lorsch[2] "talk about integration instead of the date of coordination". The diversity of understanding of integration makes it extremely difficult to determine the processes and measurable benefits that are obtained through the integration of collective transport in the area of several local government administration units. Integrations are considered as a process that is to contribute to reducing disparities and to co-ordinate many collective transport operators in a coordinated way. In academic publications on management, little attention is paid to this process. Briefly, it is just said that integration concerns merging and depending on many circumstances it is carried out in the forward direction (with suppliers) or backwards (in the sphere of recipients).

Professor G. Dydkowski presented extensive and comprehensive scientific deliberations and research on the integration of urban transport among many national scientists. However, the author states that "in current research in Poland there is a lack of assessments of integration in terms of costs and benefits, identification and characteristics of integration factors, and there are no models of financial flows and settlements between participants of integrated transport systems"[3]. In terms of standardization of the elements of the integrated urban transport network, a rich set of assessment tools was presented by K. Solecka in her doctoral dissertation[4].

The process of integrating the collective transport except from the mergers of municipal operators is carried out with the participation of local governments independent of each other, even those that do not have their own operator. The integration of transport should be carried out through:

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1 R.W. Gryffin, *Podstawy zarządzania organizacjami*, PWN, Warsaw 2004, p. 385.
2 J.A.F. Stoner, R.E. Freeman, D.R. Gilbert, Jr., *Kierowanie*, PWE, Warsaw 1997, p. 313.
3 G. Dydkowski, *Integracja transportu miejskiego*, Akademia Ekonomiczna, Katowice 2009, p. 32.
4 K. Solecka, *Wielokryterialna ocena wariantów zintegrowanego systemu miejskiego transportu publicznego*, Cracow University of Technology, Cracow 2013.

– coordination in setting transport tasks for all operators and merging traffic flows into one entity (timetables, connections between participating operators) and controlling transport processes. Transport capacity and safety related activities are also being coordinated;
– standardization including the setting of norms and standards for linear and point infrastructure and means of transport. Standardization is primarily subject to a common tariff and ticket distribution channels, but also rules for making additional payments by individual local governments and the division of these subsidies for operators. It is advisable that all participants of the integration meet the requirements of standards, the quality of operation.

Each of these activities can be described, but it is extremely difficult to assign a specific measure to them. "The purpose of each of these activities is to make integration contribute to the added value for the passenger". The main point is to make the transport processes (especially the speed of reaching the destination) and complementary services (ticket, tariff, information, parking, park and drive, etc.) together constitute a substitute with a positive value for a household with a car. For a household to value the collective transport more than travelling its own car.

Passengers living in a specific administered region assess the integrated public transport. In many of his works, Drucker emphasizes that "the starting point for work on a policy and management strategy must be information about the values and needs of potential customers of the company"[5] (in this case it is a potential passenger). A significant parameter of assessing the value of a service is the time of achieving travel destinations by means of collective communication, in relation to driving own car and spending of the passenger's own energy on the continuation of intentional movement. A simple but not very precise measure is to compare the frequency of transported passengers by collective transport before and after the integration.

In turn, the implementation of integration measures requires financial expenditures on investments, organization and service of integrated public transport in a given geographical area. Measuring financial expenditures and determining the effectiveness of integration is not methodically elaborated in economic sciences, as it is the case in determining the investment expenditures and the expected return on capital with regard to risk.

It is relatively easy to determine the expenditures on infrastructure elements involved in integration (stops, sheds, loops, etc.) and movable assets (rolling stock, IT hardware and even training). In this case, the risk results from the use of these tangible and intangible investments in a rational way. An example are mobile ticket devices inside vehicles. Their use is negligible by passengers and is therefore not applicable in many European cities. The incurred expenditures on investments and operations of collective transport integration may not always lead to a reduction of costs incurred before the integration of public transport in the region.

An important feature of integrated collective transport is the restriction of intra-industry and inter-industry competition. The lack of competition in the long run leads to the weakening of the dynamics of changes within the passenger

[5] P. Drucker, *Zarządzanie w XXI wieku*, Muza, Warsaw 2000, p. 29.

transport system, because stagnation occurs. The impulse of innovative changes can only be given by the administrative unit that "manages" the integration process.

3. Organizing transport integration at the regional level

Integration in both the design and the process of operation should be implemented by a specialized organizational unit. This unit should be staffed with a human team with an appropriate knowledge, equipped with modern information and communication technology (IT) and having the authority to act as an "integrator". The organizational unit should be legally located in the structure of local government. The legal form should be adapted to the size of the geographical area where the integration of public transport is undertaken. Examples are provided by practice (a communal union, a metropolitan union, an organizer at the level of a county or several counties). There are no theoretical premises to indicate what organizational and legal form may have an "integrator"[6] – the organizer, be it a private-public partnership (PPP), or a municipal company, or a budgetary company, or a private investor. It is advisable that the legal form of the organizer itself allows a business approach to meet the set tasks of the integrated transport systems at a regional level.

In any case, the strategic and tactical tasks facing the integration process are developed by a specialized organizational unit, but the final version of these solutions is approved by the authorities of the participating territorial governments. The exercise of organizational power in the scope of integrating public transport requires the proper value of intellectual capital and material capital financing the project and the integration process. The organizer, in accordance with the requirements of the new economy, should have adequate intellectual capital, whose core is knowledge and IT technologies. With the significant potential of intellectual capital, it is possible to rationally realize:

1) the design of the regional public transport system in these ranges:
   a) material: communication infrastructure, rolling stock, money flow paths, passenger flows,
   b) informative: timetables, tariff prices (approved by the local government), passenger information, organizational and legal regulations in relation local government – organizer – operator – passenger,
   c) setting standards-parameters, quality of offered products;
2) management of the integration process, i.e. operational planning of the network timetable, organization – coordination and assignment of tasks to operators, control of transport performance and evaluation of the value of products sold; offered transport lines;
3) regulations on the flow of money between the passenger, ticket distributors, local government budgets, operators and other stakeholders;

[6] In the further part of the article, the name "integrator" will be replaced with the commonly-accepted name of the organizer.

4) developing change strategies in the field of: telematics, the structure of new rolling stock, availability of passenger products, virtualization of the ticket system, execution control, creating added value for the passenger.

The basic component of intellectual capital is human capital, i.e. employees with knowledge about:

– methods of determination, quality (access, availability, safety, etc.) and tariff prices of products that will be in demand with potential passengers on the local regional market;
– use of appropriate algorithms and IT techniques in the design of a communication network, timetable planning, distribution of fares ("ticket") and availability of information for the passenger. A similar scope of knowledge and skills is necessary to determine the demand, the amount of revenues, costs, financial settlements, and adjustments to the current activity;
– introducing innovative changes to the passenger transport system, in order to constantly create new values added for passengers.

An element of intellectual capital is social capital, defined as knowledge accumulated and developed by means of relations between employees, partners, clients and suppliers[7]. It is generally about identifying sources from which the necessary information will be collected to design, plan and modify the collective transport system in the region. The regional organizer should have a network of information connections between all clients and other elements of the environment. The most important bond is the bond with the passenger – the customer. These ties make it possible to conduct a dialogue with passengers (e.g. via the Internet, skype, telephone, correspondence, occasional collective meetings). Information ties with clients allow for taking actions called managing relations with passengers (CRM). The management of passenger relations is ultimately a very good understanding of passenger demand. There is also a knowledge of methods in the management of "demand for driving your own car", as a substitution service for public transport

The last element of intellectual capital is the organizational capital, which includes: organizational culture, strategy and structure of the organizer and acquiring new knowledge. The basic task is to manage knowledge and acquire new knowledge so that you can introduce new technological solutions, e.g. using new IT.

4. Impact of clients on the implementation of the integration of public transport at the regional level

The need to integrate public transport in the area of the urban agglomeration or several counties or the metropolitan area or the communal relationship is convinced by the local authorities, operators and the local community. The most often emphasized argument in the assessment of local politicians is the possibility of paying for one single "integrated ticket" throughout the area served by collective transport. The fulfillment of this postulate as demonstrated by practice is not implemented

[7] A. Baron, M. Armstrong, *Zarządzanie kapitałem ludzkim*, Oficyna a Wolters Kluwer Business, Cracow 2008, p. 27.

effectively. Urban agglomerations serviced by one or several bus carriers gain full success.

The reason for limiting the effectiveness of implementing full integration is to defend the interests of each local government involved in transport integration. The lifeblood of integration is the cash flow in which the following are involved: passengers (source of money), local government administrations (source of money), organizer of integration (money flow regulator), operators (money recipients) and organizations providing complementary services (money recipients). Each of the clients assumes that as a result of integration, they will gain benefits from this process. Since the public transport operation is by definition deficient, the main source of the stream of money are subsidies from local government budgets and a much smaller source are the revenues from tickets sold to passengers. These two sources of the stream of money should cover the amount of payment for the services of the "integrator" – the organizer, complementary services and transport activities of the operators.

Balancing the flow of money is reduced to two economic category equations:

1) $\Sigma_1^n Db + \Sigma Pb = \Sigma_1^m Pwkm + Kor + Pk$ (the level of local government administration);
2) $\Sigma_1^m Pwkm - \Sigma_1^m K = \Sigma_1^m Zop$ (level of performers);

where:
Db – subsidies from local government budgets,
Pb – revenues from tickets,
Pwkm – payment to operators for transported in wkm (revenues of operators),
Kor – costs of the organizer,
Pk – other costs,
K – operator costs,
Zop – gross profit of operators,
n – number of local governments,
m – number of operators.

Balancing the flow of money rests only on the side of local governments, because the planned cash amount from the sale of tickets, as a rule, deviates from the real income in minus and exceptionally in plus. Revenues from tickets sold depend on the attendance and structure of travellers and so far have a downward tendency. In turn, operators and other service providers increase the valuation of their services, which results in imbalance and all local governments from their own budget balance the balance of the flow of money.

Individual governments are very cautious in deciding how to spend money on investments necessary to start integration and incur the operating costs of integrated public transport. Administrative units of local governments base their findings on the opinions of local politicians (councilors) supported by the information of their own operator. The amounts of these expenditures are compared with expenditures previously incurred and often indicate an increase in expenditure from the local government budget. That is why, on the joint local government forum, the expenses for integration are subject to disputes and negotiations. The question is why "our" local government is to incur so much expenditure on integration in comparison to other local governments or expenses incurred before integration?

Many residents may not take advantage of the anticipated scope of integrated mass transport services (they will still use a car or bicycle), or the number of inhabitants will decrease and the age structure of the population will change, which in terms of incurred expenses for investments and operations reduces economic efficiency integration.

On the other hand, the operators participating in the integration system want to obtain a possibly wider range of outsourced transport services in relation to the state from before integration. Here the problem of rationalization of communication connections and their transport service arises. The essence of integration is the rationalization of operation. Thus, through the coordination of transport tasks, it is possible to reduce the sum of vehicle kilometers traveled (eliminating crossed transport, reducing the sum of empty runs etc.), without reducing the frequency of running vehicles on the network of communication links. Rationalization will result in a reduction of the total number of vehicles for transport services, and thus reduction of revenues by a particular operator, and possibly a rise by other operators.

5. Tariff-ticket barrier in the implementation of transport integration in the region

In each innovative system change, designers and decision makers encounter limitations and barriers to their implementation. While the limitations are relatively easy to overcome, the barriers prevent innovations. The tariff-ticket systems used in Poland's agglomerations are just such a barrier to integrating transport in the region. The tariff-ticket system was supposed to contribute to three goals:

– provide privileges in fees to certain population groups when using public transport services; in extreme cases, the collection of fees from all residents was discontinued;
– increase the availability of tickets by expanding ticket distribution channels;
– motivate car owners to use public transport more often.

The extensive system of distribution channels and price privileges in the tariff for several groups of passengers differs in the area of each municipality participating in the integration of mass transport. In addition, participation in the integration of rail transport (regional, suburban train) is possible where the tariff is "unchangeable". Hybrid system was created in the field of price information carriers (money, paper, various cards, information on a mobile phone) and many price rates (e.g.: 24/7, concessionary, temporary, depending on the speed of travel, separate for rail transport, family, city cards, Sunday collective, etc.) at various points of purchase (driver, stationary ticket machine, mobile ticket machine, ticket points). In addition, there is a relative independence of IT software in each municipality and special "interfaces" should be built to integrate the process of distribution and information on tariff assessments. This whole complexity should have the same standards according to the recommendation of integration theory. Building a matrix with tariff rates and types of ticket purchase as well as the method of ticket cancellation indicates hundreds of possibilities that can be used by a group of passengers traveling

by public transport. The tariff-ticket system and the distribution system required investment costs and costs for operation and maintenance. The integrated system should maintain the simplicity of solutions. In many European cities much simpler solutions are used, in which the electronic medium dominates and the purchase of a traditional ticket takes place in three types of sales: driver-bus, stationary ticket machine, special ticket sales points operated by the organizer of transport. Mobile ticket machines inside the vehicle are not used in European cities.

Conclusions

Operators' activity in servicing public transport is characterized by relatively stable regular transport tasks and the lack of competition and planned deficit are features that favour the integration process. However, the following conditions must be met in order for the integration process to proceed effectively:

– the organizer's unit should have a human team with a high level of intellectual capital;
– bring standardization of elements subject to the integration of the transport system, especially the ticket-tariff system;
– negotiate a consensus in determining the expenses for the project, investments and the operational process of integrating regional public transport among the participating local governments;
– it should be clearly shown that integration will bring advantageous utility to a large population of passengers.

Practical observations indicate that failure to meet these organizational and economic conditions in the integration of public transport will take several years and will not meet the expected benefits expressed in the form of added value.

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MODERN EQUIPMENT TRANSPORT SOLUTIONS FOR STREAMLINING DELIVERIES WITHIN THE FRAMEWORK OF "THE LAST MILE LOGISTICS"

Abstract

"The last mile", although it is the final but also extremely important and generating a considerable challenge element of the supply chain. As a result, for transport operators, transport on the last part of road, to the door of each end customer, is sometimes the most expensive and the most problematic. Therefore, without the implementation of new solutions and vehicles, it will not be possible to increase efficiency in completing tasks – i.e. the increase in the number of successfully completed deliveries required by the market, while limiting the cost and time of each single delivery. The article is based on the analysis of the latest scientific and primary commercial studies devoted to this issue, supplemented with own conclusions and observations of the author.

Keywords: transport, last mile logistics

Introduction

The term "last mile logistics" refers to a phenomenon that in the organization itself and the implementation of shipments is not anything new. However, recently, it has definitely gained in importance due to changes in the transport and logistics systems for the distribution of goods on the usually final sections of the process.

The last mile logistics can be defined as a set of related organizational activities in the areas of transport and logistics, regarding delivery at the last part of road, and precisely delivery of shipments to end customers. Although this segment is the shortest in the entire displacement chain, but because of the scale of challenges and problems associated with it, it often turns out to be the most expensive and the most difficult in real execution. Of course, it must be emphasized that

the term "last mile" is used only for illustrative purposes, as it does not only concern only the "last mile", but the entire last part. This is often replaced by the equivalent term "last kilometer". These expressions can therefore be used fully interchangeably, but the first of them has gained much more popularity and is therefore often used.

The problem of deliveries under the so-called last mile logistics concerns mainly actual contractors-operators of these deliveries. They are usually suppliers of letters, parcels and courier parcels, seller of mail and food suppliers on the phone. The last part of the road – to the door/to the door of end customers, due to the size of the challenges standing here, requires the implementation of a number of optimization solutions, which do not have to be implemented on such a scale on earlier stages. These challenges are a derivative of changes in the market for purchases of goods and services and related changes in consumer behavior and expectations.

The purpose of this article is to indicate new equipment and vehicle solutions, in conjunction with changes simultaneously implemented in the organization systems themselves and the implementation of "last mile" deliveries, aimed at increasing efficiency in fulfilling these tasks – i.e. the increase in the number of successfully completed delivery operations required by the market, while reducing the cost and delivery time of each individual delivery. The article is based on the analysis of the latest scientific and primary commercial studies devoted to this issue, supplemented with own conclusions and observations made by the author.

1. Searching for modern equipment solutions

Currently, transport and logistics entities – in order to be able to fully meet the requirements of their clients – must skillfully face challenges in various urban spaces. In their activities, they must therefore take into account the constantly growing individualization of production and trade, including the dispersion of delivery and collection points, and the increasing amount of goods in delivery with smaller shipments. In addition, there are many regulations and policies of numerous cities – mainly large agglomerations, aimed at eliminating vehicle traffic from centers. In addition, considerations should take into account the significant individualization of the environment, as external factors determining efficient and effective performance of tasks are different in every large city.

That is why recently entities that carry out transport within the so-called last mile logistics are increasingly reaching for innovative technological solutions[1]. They are to allow them to raise the level and method of customer service to an even higher level. The source of such creative solutions are, among others 'big data' collection, i.e. a huge amount of data available at hand, which can be a method to help suppliers improve the delivery process. In addition, there was a need to create adapted delivery places – urban logistics centers – in densely populated urban areas and/or around them. The answer to the dynamic growth of e-commerce is also the increased demand for logistic and warehouse space adjusted to the specificity

[1] https://www.supplychaindive.com/news/last-mile-spotlight-trends-tech-gig-perfect/443091/ (access: 10.03.2018).

of the industry. All these factors stimulate the development of the "last mile" sector and contribute to the development of the market of small storage modules cooperating with central warehouses. Thus, it comes to the creation of completely new supply systems based on changes in the distribution systems themselves and – in this context – changes in the structure and network of the existing storage system and the very concept of moving goods between individual components of the system. These changes cause not only the necessity to implement a different approach by logistic operators, but also direct transport companies that execute orders for them.

The goals of the changes made on the side of transport service include:

– acceleration of the processes carried out;
– physical offload of couriers at work – less effort will be required to perform specific tasks on their part;
– decrease of relative costs – in terms of shipment – of deliveries;
– reducing the number of people and equipment necessary to perform a given job – the removal of a specified number of shipments on a given day of work.

As a result, if only transport entities that perform tasks within the framework of logistic "last mile" delivery systems are taken into consideration, the higher and higher demands and challenges posed to them necessitate:

– appropriately oriented cost optimization;
– maintaining high flexibility, including demonstrating high innovation and the need for quick response to changes;
– creating – developing new business models;
– investing in new types of transport equipment.

In the sphere of equipment itself[2], growing diversification is becoming more and more distinct. It manifests itself on the one hand with the appearance of new types of vehicles, on the other hand with the constantly increasing degree of taking over by existing vehicles the mobile functions of transport-handling-depot sub-stations. The result is the creation of transport hybrids: current light tonnage class vehicles – classic delivery trucks with a maximum authorized mass up to 6.000–7.500 kg and medium tonnage class trucks with a maximum authorized mass from 7.500–18.000 kg, simultaneously perform two functions:

– as before, the means of transport from the receiving warehouse, but not – as before – to the final recipient, but to a specific place near at least several places of final reception – locations of several recipients;
– a new function – performing the role of a base – a dock – depot for another mode of transport, which draws from them specific shipments to specified recipients and delivers them – in accordance with the given work algorithm – to these final recipients. This new means of transport in a mass system is a micro-mass – with a maximum mass from several dozen to a maximum of several hundred kilos, taking from several, several to several dozens, less often several hundred kilograms of cargo (up to 200–300 kg) and capable of autonomous, semi-autonomous or still classical move within a radius of several hundred meters to a maximum of a few

[2] T. Schiller, M. Maier, M. Büchle, *Global Truck Study 2016: The truck industry in transition*, Deloitte, 2017, https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-manufacturing--global-truck-study-the-truck-industry-in-transition.pdf (access: 8.03.2018).

kilometers from the dock-station. Such measures may include: self-propelled works – road drones, aerial drones, electric delivery vans and light delivery vans for final delivery operations.

Hence the marked dualization of their use and the hybridization of application. Other key processes are:

– autonomy of movement;
– limited or zero noise and harmful emissions. As a result, there must be an even stronger transition towards the use of alternative fuels and alternative drive units, the latter more and more often based solely on fully electric systems. Such systems ensure the required here: silent and zero emission of pollutants in connection with their other advantages – good accelerations, suited to the implementation of frequent start & stop operations or the ability to recuperate and store the recovered electricity on board;
– increasing networking – networking.

In such circumstances, the existing delivery vehicle begins to act as a mobile base – a mobile dock for vehicles delivering on the last episode. It is therefore a vehicle directly responsible for delivery and logistics before the "last mile", while transported and/or transportable micro-carriers are already delivering as part of this "last mile". These micro-drives distinguish:

– high environmental performance – in practice, it only focuses on solutions with fully electric drive units that do not emit harmful substances and emit low noise levels;
– little occupied space – it is about 1 to 2–3 m^2;
– moving – in the case of road vehicles – at low speed, usually not exceeding 10–15 km/h;
– preparation for semi-autonomous or fully autonomous movement, with compliance with all safety standards and standards in this respect;
– ability to operate in a network environment;
– ability to handle after a single load from one to at least several final recipients;
– use in the construction of many of the latest solutions, materials, technologies and software.

As a result, it should be assumed that the basic means of transport used until now ceases to be the only such measure on the last stretch of shipment of a given shipment – from the final magazine to the final recipient. In this model, it becomes a mobile subhab magazine, cooperating with other modes of transport, carrying out the movement at the very end, as part of the "last mile". These means may be taken by the basic means of transport taken together with shipments from the warehouse or may be waiting for it or used independently.

2. Factors considered when introducing special means of transport for "last mile logistics"

The key factors taken into account by carriers and operators and determining the advisability of using a special means of transport operated under the "last mile" systems are as follows:

– purchase price;
– operating and service costs – full so-called total costs of ownership and disposal (TCO);
– absorbing people's work – the need for the operator to engage in ongoing service;
– energy efficiency;
– operational utility: the ability to perform a given job – carrying out specific transport tasks at a given time and – on this basis – the ability to effectively end up the work previously performed by people;
– protection of autonomous and semi-autonomous systems against unauthorized access;
– the possibility of effective implementation of tasks under specific road and weather conditions;
– additional equipment requirements for feeder transport – how extensive and deep modifications are necessary to introduce in previously used vehicles so that they can fully and effectively cooperate with special means of transport as part of last mile movements – i.e. can existing vehicles be used, existing vehicles after necessary modifications or it is necessary to introduce vehicles of other mass/tonnage categories with specially selected buildings.

These factors influence the decision to use, under certain conditions, with certain organizational, economic and operational constraints, the specific means of transport operated under the "last mile" systems.

3. Basic advantages and disadvantages of new shipment measures implemented for use in last mile delivery systems

From the equipment side, the most commonly considered, tested or even implemented equipment solutions are[3]:
– light and medium air drones[4];
– road drones – autonomous mobile robots – autonomous moving supply robots: intelligently in an automated way – managed vehicles, known in English as smart automated guided vehicles [AGV];
– special bicycles, electrically assisted bicycles and electric scooters. A representative of vehicles of this type is, for example, a new DHL City Hub bicycle, tested as part of the pilot program[5];

[3] https://fleetstreet.michelin-solutions.com/pl/2017/05/17/logistyka-na-ostatnim-kilometrze-koniec-pewnego-swiata/ (access: 7.03.2018).
[4] http://www.inboundlogistics.com/cms/article/drones-in-last-mile-logistics-hype-or-help/; https://www.supplychaindive.com/news/robots-drones-find-solution-for-the-last-mile-and-emergency-delivery/426951/ (access: 6.03.2018).
[5] http://www.dpdhl.com/en/media_relations/specials/e-mobility.html; http://www.dpdhl.com/en/media_relations/press_releases/2017/dhl_expands_green_urban_delivery_city_hub_cargo_bicycles.html (access: 7.03.2018).

– special electric forklift trucks and other light vehicles with a maximum authorized weight up to 3.500 kg[6]. These vehicles can already be structurally prepared for fully autonomous movement[7].

All of them are suitable for specific applications under certain conditions and according to the author, based on his research, show certain advantages and disadvantages (Table 1).

An unambiguous assessment of the presented special vehicles – transport solutions for deliveries under the so-called last mile logistics is therefore not possible. In fact, specific advantages and disadvantages can be seen very individually. Certain elements for some buyers, such as a higher price, may not be decisive, for others they will be a key barrier when making purchase decisions. Similarly, ambiguity in the assessment are issues related to ecology – for ecologically aware users in highly developed countries, this factor may play such an important role that they will be able to pay more for more expensive supplies with a more environmentally friendly fleet. At the same time, in poorer societies, the real inclination to pay more for ecology may be none or small. In addition, there are different labor costs in different countries – at high costs, the tendency to support or replace human work may be higher than at lower costs.

In addition, some of these types of vehicles require support in the form of another vehicle, fulfilling for them the role of a mobile – subhub. For drones, autonomous robots and possibly electrically assisted bicycles of such subhub can be a light-class delivery van, preferably a van with a permissible gross weight from 3.000 to 7.500 kg. The electric delivery truck, however, already requires a heavier car, in the form of a tonnage class truck at least average, as in the French project BIL – Base Intelligente de Logistique by Libner[8]. Therefore, it can be assumed that the following requirements will appear for modifying the basic means of transport:

– drones – roof modifications, possible modifications in the building space;
– autonomous delivery works – modifications inside buildings;
– forklift trucks – a vehicle-carrier from a heavier mass category – medium instead of lightweight, in addition to a specially constructed structure for this purpose;
– electrically assisted bicycles, scooters – it is possible to leave previously used delivery vehicles, if only at certain points they will be reloaded on bicycles parcels or unified containers with parcels, or some modifications inside the body, if it serves as an exit base for these bikes.

As a result, the smallest alterations require the introduction of scooters and electrically assisted bicycles, the most and the most expensive, which are derived from the use of other car carriers with specially dedicated bodies – electric delivery trucks. Between these two categories, in the cost sphere, there are drones and mobile autonomous robots. In both cases, the costs of necessary changes and modifications, however, will not be exorbitant.

[6] http://www.dpdhl.com/en/media_relations/press_releases/2017/dhl_ford_streetscooter_work_xl.htmldata; https://www.streetscooter.eu/, https://navya.tech/en, www.nysamotors.pl (access: 10.03.2018).

[7] https://www.theverge.com/2018/1/8/16863092/toyota-e-palette-self-driving-car-ev-ces-2018; https://www.toyota.ca/toyota/en/connect/2000/toyota-e-palette-concept-vehicle-ces-2018; http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_self_driving_vehicles.pdf (access: 7.03.2018).

[8] http://bil.libner.com/bil/en (access: 22.02.2018).

What's more, consider the subject of the universality of such specially selected bodies, i.e. how efficiently they will be able to continue to perform their tasks when they do not cooperate with special means of transport dedicated to relocate in the service of the "last mile". In this sphere, the situation is as follows:

– electrically assisted bicycles, electric scooters – the possibility of trouble-free and equally effective self-use;
– drones – the possibility of trouble-free and equally effective self-use;
– autonomous robots – the possibility of independent use with practically analogous efficiency – the space inside for works without major problems can be used as a normal cargo space for picked-up packages;
– forklifts – the possibility of independent use, but with the loss of a part of the cargo space, which in the situation does not take on board the trolley rather unlikely to be allocated to the cargo space. However, in newer solutions this option will probably appear – this space will be suitable for taking parcels, because it will be able to be equipped with a system of elastically selected attachment points for side shelves or locks in the floor and side covers in the form of a fixed door or sliding tarpaulin – a so-called curtain.

Additionally, in three cases – an electric delivery truck and an electric bicycle/bike and an electric scooter – vehicles must be driven by people. The organizational issue here concerns the issue of whether riding them will belong to the driver's duties – a courier of a delivery vehicle – subhub, or – in an accepted distribution system of parcels – shipments will be packed with them from the main vehicle and will be distributed with them by a driver other than the operator car mobile subhub. In such a system, the most mobile, autonomous delivery robots can be the most effective. What's more, they can change the supply system very much. It can even be assumed that the evolution is rapidly changing towards their more massive use. These robots are used both at the level of the warehouses themselves and the delivery of last mile deliveries in order to reduce the requirements of the workforce and its costs, and help all parties involved in the chain to meet the increasing demand – the growing turnover created by the growth in e-commerce. To a large extent, they can affect how the last mile deliveries operate – perform operations of carriers, and even how access routes to warehouses, stores or residential houses are designed and built. These robots will ultimately be able to use, among others from driveways for cars or paths for wheelchairs and people with disabilities. In addition, in places, including blocks, where elevators for wheelchairs/wheelchairs are installed, in an intelligent – independent way they will be able to use them to carry out deliveries to higher floors.

Mobile robots are more flexible to use than traditional automated handling systems – handling shipments, as the latter require permanent infrastructure. Mobile robots/intelligent autonomous vehicles that they can carry or push – as a pusher cargo to a specific location or function as intelligent, driverless trucks or lift trucks in warehouses, definitely reduce the need for labor not only at the level of the warehouses themselves or in within the distribution, but also allow for greater automation, easier installation and subsequent reconfiguration.

Table 1. Advantages and disadvantages of new types of means of transport used in the supply of so-called last mile

Vehicle type	Use	Advantages	Disadvantages
Air drones	Poorly urbanized and populated areas: rural, mountainous, islands, with difficult access, neighborhoods of loosely distributed single-family houses – residential districts	– the possibility of trouble-free access to any place, including places located far from the main communication routes or difficult access, such as islands or places with a road difficult to pass	– high costs of purchasing only professional drones – high energy expenditure necessary to perform a given task – possible susceptibility to weather conditions, such as strong rain, strong wind or intense snowfalls, and – in this context – the issue of protection against unfavorable weather conditions, such as rain or snowstorm, and their effects (wetting) – cost of additional personnel training – driver – the shipment provider becomes a drone operator – the problem of protection against interference, including the issue of proper securing of the ship against unauthorized seizure of the consignment as a result of earlier unauthorized seizure of the drone itself – the problem of protection against birds attacks – possible technical lack of preparation for taking non-standard consignments of mass and dimensions – for heavy, undersized, etc. – limiting useful payload and possibly space – drones reduce the available payload to be used to take shipments and – if they are not picked up on the roof of the vehicle – your carrier – also the cargo space – relatively low universality of use
Autonomous mobile robots	Deliveries in city centers, in office areas, to blocks	– no need to engage direct attention from the driver – operator – the ability to serve several recipients from the same location or locations located close to each other – the ability to travel on roads that are inaccessible to delivery vehicles, such as sidewalks or bicycle paths, which can shorten the delivery time and simplify it – the ability to reach many so-called closed zones for normal traffic, such as city centers – dedication to handling a few shipments in a given area – no emission of harmful substances and negligible noise emission with a fully electric drive	– problems with entering stairs, elevators, possible problems with overcoming curbs – possible problems with moving on wet, slippery, poorly or not snowed surfaces – the ability to take several dimensional shipments and the correct weight – purchase costs of the device – relatively high robot price – taking up space in the delivery vehicle and limiting its load capacity – protection against attempts to seize control and attempts to steal both the shipments themselves and the device – the robot – the problem of protection against interference, including the issue of proper securing of the ship against unauthorized seizure of the consignment as a result of an earlier unauthorized seizure of the robot – medium or low versatility of use

Supply trolleys and other fully electric vehicles with a maximum authorized weight up to 3.500 kg	Deliveries in city centers, in office areas, to blocks	– possibility of taking many parcels, including undersized ones – zero emission of harmful substances and limited noise emission – the ability to move without problems even in restricted traffic areas, including sidewalks, cycle paths, pedestrian streets – the ability to reach many so-called closed zones for normal traffic, such as city centers – dedication for handling many orders from a given area – for example, office buildings, a block of flats – significant mobility is possible, including moving on slippery or snowy surfaces – possible support of loading and unloading operations of packages thanks to the option of assembly of the elevator	– sometimes the need to use a car – a base at least of the mass medium category – from 12 000 to 18 000 kg – negative projection on the load capacity of the vehicle – base – the operator must be present in the trolley; average versatility of use – high purchase price
Bikes, electrically assisted bicycles, electric scooters	Average flexibility in application – the ability to deliver to blocks, office buildings or single-family houses	– the ability to move without any problems in restricted traffic zones, including pavements, cycle paths, pedestrian streets – relatively large transport capacity – load capacity up to 100–125 kg, loading volume of 1 m^3 – the ability to take even some non-standard items with regard to weight and dimensions – high flexibility in typical urban operation – the ability to perform tasks even directly from the transmitting warehouse or local subhub, if the final collection points are located close to it – no emission of pollutants and practically no noise emission – a relatively low purchase price	– dependence on weather conditions, mainly in winter – necessary presence of a human being to direct control

Source: own elaboration

In the case of drones, the basic advantage of using them is a derivative of the fact that they prove to be helpful, faster, easier and cheaper to get to locations that are harder to access due to the road conditions – a difficult road, a target point located on an island, for example – and/or a drone it will defeat a much shorter route than a classic vehicle would have. Such a situation may occur in rural areas or generally poorly populated areas. At the same time, the driver of a car – a mobile subhub – a base for drones, when they are operated, is only absorbed in the control and control of these devices. As a result, he cannot deal with other activities. As a result, in such situations in the delivery of shipments, the act of driving a wheeled vehicle is replaced by the act of steering the drone. In the currently tested solutions autonomous drones do not work – drone capable of independent movement, due to the high degree of technical complexity of such studies and their fairly high price.

4. The first results of research on the use of new means of relocation dedicated to deliveries under the "last mile"

Made in the second half of 2016, the third research of the German ZF focused on "Last mile logistics". These tests were carried out by the Fraunhofer Institute for Flow of Materials and Logistics (IML) – these were so-called 360-degree examination of customer expectations, statutory and spatial framework conditions as well as technical trends and their effects. The published results indicated that delivery drones are likely to remain a niche solution, but in just a few years they will definitely gain autonomous significance of work. They will be able to perform tasks effectively – daily functions, both in large cities and in rural areas[9].

The first results of practical tests assessed as part of the Robotic Delivery Systems[10] project also indicate the desirability and cost-effectiveness of implementing autonomous robots. The work is being carried out by the German Daimler concern Mercedes-Benz, cooperating with the Starship Technologies startup.

In the proposed solution, the lightweight delivery vehicle Sprinter acts as a mobile base station for delivery robots, acting as a mobile hub – a docking station. On the lower deck of the hold there is a "parking lot" for eight robots, on the upper so-called intelligent shelving with packages, and many processes are built-in automatically. Thanks to this, the courier's work becomes more efficient. In addition, the ICT system used continuously monitors the work and location of the robots to track where they are and where the vehicle should take them again. The robots themselves navigate the streets, sidewalks, streets and roads fully autonomously thanks to the combination of GPS navigation and multiple cameras. During autonomous driving, robots are able to overtake, avoid and overtake pedestrians and other obstacles encountered. Six-wheel robots type 6D63 are used here, without any problem overcoming even high curbs and safely that can use

[9] https://press.zf.com/site/press/en_de/microsites/press/list/release/release_28033.html (access: 1.03.2018).

[10] *Roboty na ostatnim kilometrze. Jak uporać się z górą przesyłek w ekonomiczny i prosty sposób? Mercedes-Benz Vans wraz ze Starship Technologies już dziś testują przyszłość*, Mercedes Transporting 2017, 4, p. 22–33.

sidewalks. They can take up to 40 pounds/18 kg of cargo and move autonomously at a foot speed within 3 miles/5 km from the vehicle base – dock. They are powered fully electrically and consequently zero emission. During their journey, their cargo containers are closed – a specific container with a given shipment can only be opened by the appropriate recipient after receiving the unique individual code received earlier. Thanks to these robots, eight parcels can be delivered at the same time, which greatly increases efficiency. The tests already carried out proved that the courier-auto-delivery-work team during the 9-hour shift is able to deliver up to 400 items, compared to 180 delivered using the existing standard service method. The above means an increase by as much as 120%. Functionally Sprinter and robots complement each other, as the robot's efficiency grows in connection with the car as a base. The system also provides support for the driver – he can do much more tasks in less time and he changes the nature of his work. He becomes a coordinator and a direct supervisor of robot work from the parcel carrier function.

In this context, the estimates of the consulting company McKinsey[11] indicate that autonomous road drones – robots in the form of mobile parcel machines will replace the current forms of regular parcel deliveries. The above results from their cost advantage by 40% and more compared to today's conventional last-mile deliveries. This advantage becomes exceptionally clear not only in rural areas, but also urban – assuming that labor costs are around EUR 20 per hour. However, this cost advantage only exists if labor costs are higher than EUR 10–12 per hour. The 40% supply savings would translate into a 15% to 20% increase in profit margins or (more likely) – considering that in this market segment price is the key decision criterion, to a 15% to 20% reduction. In the industry with margins ranging between 2% and 5%, these are significant values. In addition, as wages are likely to continue to rise, the advantage of autonomous forms of delivery will increase. At the same time, deliveries of the last mile to a much greater extent than at the moment will require the involvement of assets of significant value.

The test results with special urban reinforced bicycles are also very positive. The solution is successfully implemented, among others by the German DHL Express, which in selected countries in downtown operations replaced already 60% of vehicles with Cubicycle goods bicycles, supplemented by special City Hub trailers. Precisely, the company introduced bicycles in over 80 cities in 13 European countries, including 14 Cubicycles in seven cities. Courier Cubicycle cover an average of 50 km per day[12].

Cubicycle was established in the Netherlands and DHL implemented it in 2015 in its network. It offers many features and benefits that make it ideal for express operations. It has removable standard containers, corresponding to the dimensions of the classic transport pallet. The total cost of ownership over the entire service life remains less than half of the maintenance costs of a lightweight distribution car.

[11] M. Joerss, J. Schröder, F. Neuhaus, C. Klink, F. Mann, *Parcel delivery. The future of last mile*, Travel, Transport and Logistics 2016, September, https://www.mckinsey.com/~/media/mckinsey/industries/travel%20transport%20and%20logistics/our%20insights/how%20customer%20demands%20are%20reshaping%20last%20mile%20delivery/parcel_delivery_the_future_of_last_mile.ashx (access: 1.03.2018).

[12] http://www.dpdhl.com/en/media_relations/press_releases/2017/dhl_expands_green_urban_delivery_city_hub_cargo_bicycles.html (access: 9.03.2018).

Equally important, it generates zero emissions, thus minimizing the negative impact on the environment and supports the efforts of municipal authorities to promote sustainable living in the city.

At this stage, such aided bikes are useful in this complex ecosystem, occurring instead of typical vans in heavily urbanized areas – densely populated, with difficult access.

In addition, despite some indications, some encouraging results are obtained with regard to drones. At the end of November 2017[13], Mercedes-Benz completed a three-week test program at Zurich in Switzerland, which used its delivery trucks and drones. This program was carried out together with the American manufacturer of drones Matternet and the Swiss internet portal Siroop. Customers who ordered selected products for roasting coffee from a local company, on the same day received the opportunity to use the delivery with the help of a drone. Mercedes claims it has delivered 100 deliveries to 50 customers with a 100% delivery rate, delivering packages up to 11 miles. At the same time, drones moved parcels not directly to the consumer, but to Mercedes vehicles in four pre-determined locations in the city. Then the packages were transported by van for a short distance to each address. The Vans and Drones program aims to shorten delivery time bypassing traffic in densely populated areas. His goal is to ultimately synchronize the drones and fleet of vans, so that the buyers do not have to drive to pre-established pick-up points, and pick up from vans on a regular route.

Conclusions

At present, the entire transport ecosystem must face new pressures and requirements from many sides. Most customers – buyers want more options, which results in a growing pressure on their wider and deeper individualization of service. It is because of the fact that a number of factors and phenomena in the environment support this. In this context, it is worth noting that: digitization create more opportunities and alternatives, in urban areas there are new delivery concepts, where destinations and recipients are concentrated – aggregated, resource sharing – assets change the meaning and the "ownership" account – ownership, and alternative types of vehicles can change the way in which time and work affect the financial result. At the same time, because goods will have to be physically moved further at individual stages, all changes implemented today relate to the cost-effectiveness, time and resources of this process, i.e. to make this movement relatively cheaper, faster and with reduced environmental footprints. At the same time, people have always tried to supplement or replace the work of animals and machines. For years, however, there were two major barriers to replace partially or completely the work of people. The most serious of these barriers included cost and technology factors. Now autonomous vehicles/robots begin to overcome this traditional trade-off between efficiency and flexibility, and the situation in this area is constantly

[13] http://www.automotive-fleet.com/channel/van/news/story/2017/11/mercedes-benz-considers-drone--test-program-a-success.aspx (access: 10.03.2018).

improving due to improvements successively introduced in the robots themselves and as a derivative of the industry/sector gaining more and more experience related to their service.

Generally changes in delivery systems within the so-called last mile logistics are heading to the fact that these deliveries will take place through a dynamic network, what flexibility is based on performance and demand and depends on them. And in this scenario, the majority of innovations are implemented as part of the last mile. Companies, distribution centers and carriers physically moving parcels even over a distance of thousands of miles – they all have to implement a completely new approach. Particular importance will be given to it:

– extremely large individualization of the approach – adopted strategy in the area of used means of transport. There is no one perfect exit. Technologies must be selected on a case-by-case basis, with strong regard to the specificity of a given area, including its availability and/or recorded traffic volume, unique preferences of recipients, including their consent to pay for certain things, and cost and personal factors, including availability manpower, its costs and costs and benefits connected with its partial or total subsidence by modern technologies;
– flexibility in use – as the criterion adopted here refers to the possibility of full-time vehicles currently used in classical distribution as part of the "last mile logistics". These vehicles are light commercial vehicles, mostly mass category up to 7.500 kg permissible total weight.

What's more, any sensible potential means of delivery can be effectively used in this system. It can be not only drones and robots or special bikes, but also cyclists, walkers, individual drivers, taxis – that is everyone who is available at a given moment in a given area, to safely, reliably and on time deliver a package from point A to point B. As a result, even relatively low-tech advanced solutions can turn out to be extremely cost-effective, efficient and effective when the last mile deliveries issue. In addition, suppliers and resellers who can be at the center of this digital ecosystem are able to grow. At the same time, while many expect consolidation among players at the heart of the ecosystem, the total number of niche suppliers and informal part-time couriers is likely to grow steadily, at the very last moment effectively taking over market share.

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CYCLICAL FLUCTUATIONS IN FREIGHT TRANSPORT IN SELECTED EUROPEAN UNION COUNTRIES. SYNCHRONIZATION, OR NOT?

Abstract

Fluctuations of the economic activity in transport result from the operation of many factors of a demand and supply nature in all sectors of the economy. These factors determine both the common and specific characteristics of such fluctuations. The aim of this paper is not only to examine the morphological features of cyclical fluctuations on the transport market in Poland and selected countries of the European Union, but also the degree of their synchronization. The latter can be understood in the external context (between fluctuations in the transport production of various countries), but also in the internal one, where the subject of comparisons are fluctuations in transport and basic macroeconomic variables. The properties of business fluctuations will be examined by classical procedures for the separation of cyclical components and the detection of their turning points.

Keywords: freight transport, cyclical fluctuations

Introduction

For a long time, transport has been among the branches of the economy diagnosed from the point of view of the state and economic fluctuations. The research, which covers freight transport, was initiated in 1997 at the Motor Transport Institute. In 2004 in the Central Statistical Office, research on the economic situation in transport and storage was launched as part of the business climate survey in the services sector[1]. Such tests are usually conducted using the test method – the evaluations are based on information from a research questionnaire containing a set of questions

[1] Economic Business Study: Methodological Notebook reviewed by the Methodological Commission of the Central Statistical Office.

about qualitative changes in the situation of transport enterprises and their business environment. The detailed scope of research includes obtaining information on changes, financial situation of enterprises, their level of indebtedness, transport volumes and prices for transport services, the number of involved rolling stock, as well as subjectively perceived by transport companies barriers limiting their functioning and development. This allows to acquire information that is difficult to access or even impossible to obtain in a different way relatively quickly. As a consequence, such data also allow identification and forecasting of business fluctuations in the field of cargo transport. Encouraging results of empirical research show that the achieved values of business climate indicators in transport (and not only) are quite good in the process of formulating forecasts for "hard" characteristics of the transport sector, e.g. transport volumes and transport performance.

However, in this paper we will not deal with the issues of forecasting the economic situation, nor building models of this, limiting ourselves to the estimation of the basic characteristics of cyclical fluctuations of these hard variables describing the trucking sector. Looking somewhat forward, it can be concluded that the results of observations of fluctuations in the transport sector do not differ significantly from "stylized facts" observed in other branches of the economy.

In articles Adamowicz (2012)[2], Gradzewicz (2010)[3] and Skrzypczyński (2010)[4], the fluctuations of basic values characterizing the state of the Polish economy were analyzed: gross domestic product, added value (in sectoral terms), individual and collective consumption, export, import, employment and average salary. This allowed not only to identify cycles of the most important macroeconomic characteristics of the Polish economy, but also the degree of its synchronization with the business cycle in the European Union countries, primarily with the countries of the euro area. All these and other papers, apart from updating the empirical results themselves, also present a certain "methodological canon" in the field of business cycle research. It is part of the identification of turning points of fluctuations, with the most probably known method of Bry-Boschan, or the use of various measures of similarity in order to capture the similarities and differences in the course of cyclic fluctuations.

The rather poor remark devoted to transport research to date seems inadequate to the importance of this sector for the whole economy, not only Poland. This work is intended as (very) modest attempt to change this state of affairs.

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[2] E. Adamowicz, S. Dudek, D. Pachucki, K. Walczyk, *Wahania cykliczne w Polsce i strefie euro*, SGH Warsaw School of Economics Publisher, Warsaw 2012.

[3] M. Gradzewicz, J. Growiec, J. Hagemejer, P. Popowski, *Cykl koniunkturalny w Polsce – wnioski z analizy spektralnej*, Bank and Credit 2010, 41(5), p. 41–76.

[4] P. Skrzypczyński, *Metody spektralne w analizie cyklu koniunkturalnego gospodarki polskiej*, National Bank of Poland, series: Materials and Studies, Paper No. 252, 2010.

1. Research methodology

The research was carried out in the convention of the growth cycle (cycle of deviations[5]), where the cyclical components of variables characterizing the freight transport market and its economic environment are the subject of the analysis. The cyclical components themselves are not directly observed, and their separation requires the removal of the long-term path of changes, i.e. the trend. There is no single – canonical procedure – decomposition of time series, although the methods most commonly used in this area can be indicated. They have also been used in this work. Cyclic components of all series were estimated using the Christiano-Fitzgerald filter[6], eliminating both short-term fluctuations (accidental and seasonal fluctuations) as well as long-term fluctuations (trend). The frequency response of the filter covered periods from 2 to 10 years, corresponding to typical economic fluctuations. Both the trend and deviations from it may refer to the value of the variable itself (y_t), or – more rarely – the rate of its change calculated according to the formula:

$$r_t = \frac{y_{t+1} - y_t}{y_t}.$$

The position of turning points of cyclical components was estimated using the Bry-Boschan method[7], dedicated to quarterly data. In the case of time series with relatively mild runs (and in the present considerations dealing with such series of cyclic components), turning points correspond to the local extremes of these series.

Regardless of whether the analyzed variable belonged to the "hard" or "soft" categories (results of questionnaire surveys), the course of action was as follows:

Time series ("raw data") ⟶ Cyclic component ⟶ Turning points.

Cyclic components illustrating fluctuations around the long-term trend allow distinguishing the growth and downward phases. The first one is the period of increased activity, characterized by a location above the trend line, the second one is accompanied by a slowdown in activity with the production volume below the trend line. Let us emphasize that the relegation and growth phases refer to cyclical components. Considering the fact that trends of observed values are increasing functions of time (this is the case for each variable discussed in this paper) and relatively small amplitudes of cyclic component variations, it can be concluded that in both phases the variable values are increasing, however, this increase is slowed down or accelerated compared to their long-term trends. These phases distribute the turning points (PZ): the bottom (D) corresponding to the transition from the declining phase to the growth phase and the upper one (G) in which the change in economic activity runs in the opposite direction.

[5] I. Mintz, *Dating Postwar Business Cycles: Methods and Their Applications to Western Germany, 1950–1967*, National Bureau of Economic Research, Cambridge 1969.

[6] L.J. Christiano, T.J. Fitzgerald, *The Band Pass Filter*, International Economic Review 2003, 44(2), p. 435–465.

[7] Cf. G. Bry, Ch. Boschan, *Cyclical Analysis of Time Series*, Technical Papers of NBER 1971, 20; D. Harding, A. Pagan, *Dissecting the Cycle: A Methodological Investigation*, Journal of Monetary Economics 2002, 49(2), p. 365–381.

The identification of the turning points of the fluctuations, in turn, makes it possible to distinguish the growth phases (phases D-G, i.e. counting from the lower turning point to the next higher) and downward phases (G-D phases, counted from the upper turning point to the next lower turning point). This gives the possibility to determine the duration of said phases as well as full cycles defined as periods between successive lower or upper turning points (respectively D-G-D and G-D-G).

The simplest version of the classic fluctuation synchronization test method uses correlation coefficients between time series and time shifted copies of these series (so that the magnitude of the time shift, or the phase difference of these series). Unfortunately, the correlation coefficient itself is not a relatively resistant measure, remaining sensitive to atypical observations ("outliers"). Therefore, in order to examine the degree of similarity of fluctuations, and more precisely the similarities of the PZ positions of these fluctuations (and disregarding their amplitudes), additional measures of similarity were defined. They are not sensitive to changes in the amplitude of these fluctuations, they depend only on the location of their turning points.

For a given time series $(x_t)_{t\in T}$, we create a series $(x_t^d)_{t\in T}$ defined as follows: $x_t^d = 1$ if the quarter t is the upper turning point or t belongs to the recovery phase (i.e. the nearest to the future turning point is the upper point). Otherwise, we accept $x_t^d = -1$. For such constructed series $(x_t^d)_{t\in T_1}$, $(y_t^d)_{t\in T_2}$ for which $T: = T_1 \cap T_2 \neq \varnothing$ the following measures of similarity in the period can be defined in a natural way T:

$$\mu_1(x^d, y^d) = \Sigma_{t\in T}\, x_t^d\, y_t^d / |T|, \tag{1}$$

(where $|T|$ is the number of elements of the set T) and

$$\mu_2(x^d, y^d) = \Sigma_{t\in T}\, |x_t^d - y_t^d| / |T|. \tag{2}$$

These measures can be used to check whether one of these series can be considered as ahead of the other. The basis for such analysis may be the comparison of the similarity of one series with the time-shifted copy of the other. A measure of such anticipation are therefore the numbers:

$$r_1^* = \operatorname{argmax}(\mu_1(x^d, L^r y^d): r = -z, ..., z) \tag{3}$$

$$r_2^* = \operatorname{argmin}(\mu_2(x^d, L^r y^d): r = -z, ..., z) \tag{4}$$

where z is an arbitrarily set number defining the scope of the series shifts considered y^d, L^r means the operator of withdrawing over time the series by r periods (i.e. $(L^r y)_t = y_{t-r}$). Note that if $r_1^* < 0$, in the sense of measure μ_1, the series y^d precedes x^d (and so the variations of the cyclic component y of the series are preceded by fluctuations of such a component of the series x). Similarly, if $r_1^* > 0$, in the sense of measure μ_1, the series x^d precedes y^d. From the point of view of the measure (1), and more precisely the criterion of its maximization, the simultaneous fluctuation can be said when $r_1^* = 0$. The analogous interpretation can be given in size .

The determination of these values for the time series of the analyzed variables may provide some indication as to the degree of similarity of their cyclical fluctuations. Cyclical changes in transport performance in Poland.

This part contains a summary of the results of empirical studies of cyclical fluctuations in transport production in Poland and some neighboring countries. The considerations are divided into two parts. In the first one, we discuss the results of research on fluctuations in cyclical variables characterizing the transport sector in Poland – the volume of transport and transport work. The second part is a short international review in the area under consideration. The calculations were made using the original procedures written in the R statistical packet.

In the case of Poland, the data used in the study came from the Central Statistical Office resources. Time series with a quarterly frequency included the period from the beginning of 2004 to the end of 2016 included the volume of transport and transport performance by road transport, broken down into domestic and international transport.

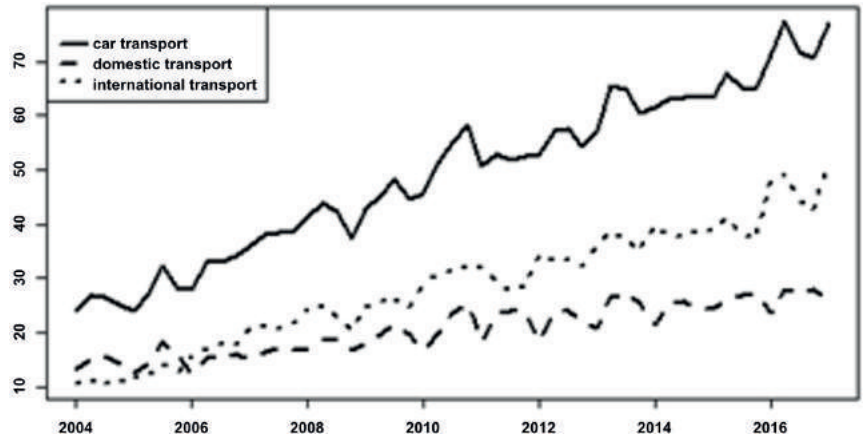

Figure 1. Transport performance in Poland, billion ton-km
Source: own elaboration based on: the CSO data

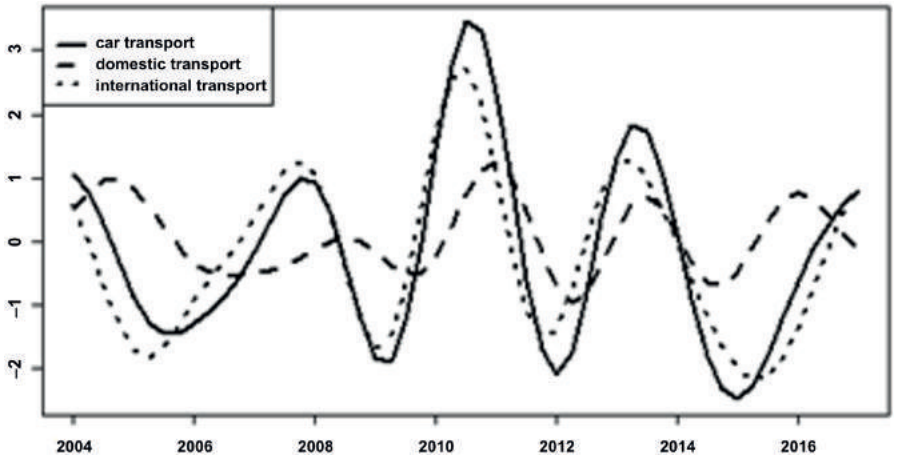

Figure 2. Cyclic components of transport performance, billion ton-km
Source: own calculations based on: the CSO data

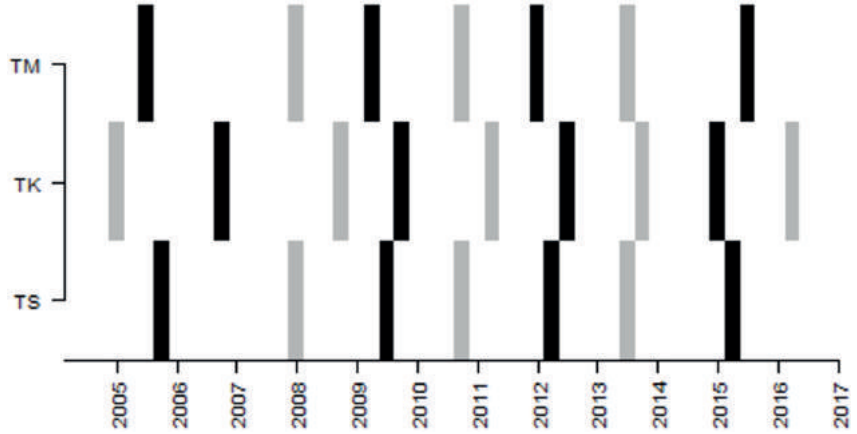

Figure 3. Position of turning points of cyclic components for transport performance
Source: own calculations based on the CSO data

The volume of transport operations by road transport (TS) and its components relating to domestic (TK) and international (TM) transport were analyzed. Plots of raw time series of these variables are presented in Figure 1, while the course, estimated using Christiano-Fitzgerald filter, cyclical components of the mentioned series is shown in Figure 2. In all considered cases, these components are characterized by a typical "mild" course, which results in their the minimum and maximum values respectively determine the lower and upper turning points of the fluctuations.

In the case of the TS variable, the upper VP was identified in the periods 2007 (4), 2010 (3) and 2013 (2), while the lower ones in 2005 (3)[8], 2009 (2), 2012 (1) and 2015 (1), which gives 3 full DGD cycles (the same type of GDG) with an average duration of about 3.2 years. Cyclical fluctuations in national transport performance are characterized by a slightly higher frequency: upper PZ correspond to the following periods: 2004 (3), 2008 (2), 2011 (1), 2013 (3), 2016 (1), and lower periods – 2006 (3), 2009 (3), 2012 (2), 2014 (4), which translates into an average length of the DGD cycle equal to 2 years and 3 quarters. When it comes to international transport, the results are close to the TS variable. Minor differences can only be seen in the lower PZ variations. The average distance between neighboring lower VPs, and therefore the length of the DGD cycle, is equal to 3.3 years.

Cyclic components of TS, TK, TM change rates are even more volatile. This translates into an increase in the number of VPs and a reduction in the average time of a single cycle. Thus, the average duration of a full DGD cycle, i.e. the time interval between neighboring lower PZ fluctuations, in the case of total road transport and domestic transport performance, is about 2.3 years. Some surprise is the relatively long average such time – almost 4 years – in the case of international transport. In the latter case, we observe a rare case in which the growth phases last shorter than inheritance.

The comparison of PZ position is facilitated by drawing 3. The upper, black – lower turning points are marked with gray color. Their position in the case of the TS,

[8] Quarter numbers are given in brackets.

TM variables is very similar: the upper PZ are basically simultaneous, while the lower ones are basically – though not always – their counterparts for the TS. The location of turning points in domestic transport (TK) is somewhat less similar to the variables. The answer to the question whether the variations of cyclical components of variables have a pre-emptive character, possibly simultaneous or delayed, is essential. The location of PZ of the variables analyzed suggests that TS fluctuations are of a pre-emptive nature to TK, whereas TM – to the other variables.

Of course, we rarely deal with a situation where always (of course, we mean only the observed time range) the turning points of one size precede their counterparts in the other. Usually this is not the case and you can only talk about the average amount of advance of one size by the other, agreeing with the situation that in some periods the position of PZ of the compared sizes will be reversed.

The basis of the diagnostics will be the average of advance (3) and (4) turning points of variables in relation to the turning points of the remaining quantities. Table 1 gives the values of these leads for all currently analyzed variable pairs. Within the meaning of both criteria – maximization of the value of measure (1) and minimization (2) – turning points of variations of the TS variable precede their counterparts in the TK variable by about 1 quarter, and TM fluctuations precede TS fluctuations by about 2 quarters. However, these criteria give different indications as to the fluctuation of the TK and TM variables. Taking into account the first criterion, TM fluctuations are ahead of the TK by about 3 quarters; the second criterion indicates, however, the "average" simultaneity of these fluctuations.

The desirable property, with no small precondition for synchronization of fluctuations, is the consistency of the times of the growth and declining phases of the compared variables. Meeting this requirement leads to (smaller or larger) compliance of the number of turning points of indicators and reference values, which allows to reduce the risk of false signals of a change in the upward or downward phase.

Table 1. Values of time shifts for which the highest similarity of cyclic fluctuations of successive pairs of compared variables (TS, TK, TM) was obtained. Each of the elements of the table contains, in turn, the offset values (3) and (4) calculated for the respective pair of variables

	TS	TK	TM
TS	–	–1, –1	2.2
TK	1.1	–	3.0
TM	–2, –2	–3.0	–

Source: own calculations based on: the CSO data

It is worth adding that Figure 3 is easily "expanded" by including information on the location of key, "hard" turning points, characteristics of the economy and transport sector (primarily GDP, exchanges with abroad, value added transport) and "soft" business climate indicators. Such a process allows to conclude that in the first part of the analyzed period (from 2004), more or less until 2011, the location of turning points of these variables is more or less regular. Turning points of business climate indicators in transport were concurrent or slightly delayed in relation to "hard" variables. As a result of the crisis which began in 2008, the synchronization of cyclical fluctuations became visible. This is clearly visible

from 2012. From that moment, the leading nature of business climate indicators is quite clearly visible in relation to the majority of "hard" variables.

2. A brief international review

Cyclical fluctuations of the economic situation in rail and road transport were observed on the basis of changes in the volume of transport performance carried out. The starting point was the data on the volume of transport performance for selected countries with different seniority in the European Union taken from the Eurostat database: Belgium (BE), Germany (DE), Spain (ES), France (FR), Italy (IT), The Netherlands (NL), Austria (AT) (for these countries the time span of the data covered the years 1999–2016); Czech Republic (CZ, period 2000 (1) – 2016 (4)), Hungary (HU, 2001 (1) – 2016 (4)) and Poland (PL, 2004 (4) – 2016 (4)).

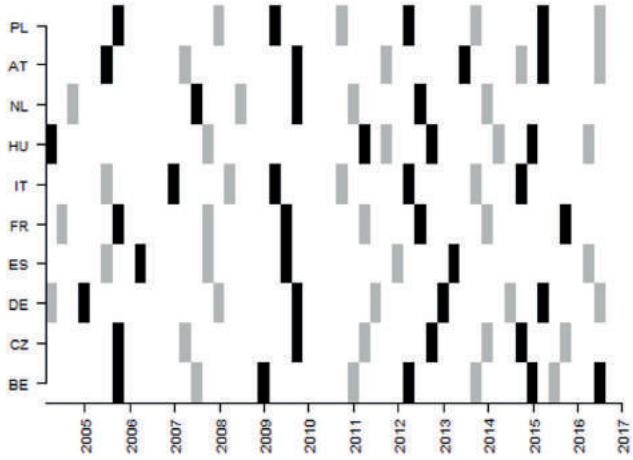

Figure 4. Location of turning points in transport performance in selected EU countries
Source: own calculations based on: data from the Eurostat database

Table 2. Basic characteristics of cyclical fluctuations in transport performance in selected countries

Country	The average time of the growth phase	The average time of the decreasing phase
BE	1.44	1.9
CZ	1.4	1.81
DE	1.7	1.6
ES	1.9	1.35
FR	1.5	1.42
IT	1.45	1.17
HU	1.69	1.75
NL	1.2	1.65
AT	1.38	1.38
PL	1.62	1.42

Source: own calculations based on: data from the Eurostat database

Table 3. Values of time shifts (3), (4) between cyclical fluctuations in transport performance in Poland and in selected EU countries

	BE	DE	ES	FR	IT	HU	NL	AT
measure (1)	0.26	0.36	–0.03	0.20	–0.13	0.31	0.26	–0.23
shift 3)	2	3	–2	–2	–2	0	0	3
measure (2)	0.16	0.15	0.20	0.17	0.21	0.16	0.16	0.22
shift (4)	2	3	–2	–2	1	0	0	3

Source: own calculations based on: data from the Eurostat database

The average lengths of growth and decreasing phases, estimated for the countries studied, fluctuate within the same limits, namely 1.20–1.90. They do not differ significantly from the results obtained for Poland. The longest average duration of decreasing phases is recorded for Spain. In turn, in terms of growth phases, the longest average is observed in the transport sector of Belgium and the Czech Republic, and the shortest in Italy (see Table 2).

In most cases we observe similar numbers of PZ. Their position is shown in Figure 4. Their distribution is basically fairly regular, although a small increase in their occurrence (and as a consequence, a reduction in the average time of decreasing and growth phases) has been recorded since 2010, that is, the time following the recent global crisis. Both in the period preceding the crisis and later, we observe a relatively good PD synchronization. Period of 2007-mid-2008 corresponds to the end of the acceleration phase (upper PZ); period 2009–2010 is the end of the decreasing phase and the beginning of acceleration. At the end of 2011, the next phase of the slowdown begins, the end of which falls on the next year. The next transition from the acceleration phase to the slowdown phase takes place at the turn of 2013 and 2014. Period of 2015 until the beginning of 2017 is generally the acceleration time. Of course, the inflow of subsequent data may cause the need to modify the position of the last VPs to change the time limits of cycle phases.

The extreme values (respectively maximum and minimum) of the similarity measures (1) and (2) between the transport cycles of Poland and the EU Member States surveyed are included in Table 3. Cyclic fluctuations in transport performance in Poland usually precede such fluctuations in Spain and France. These overtures are not significant. Simultaneous character seems to have fluctuations in transport performance in the Netherlands and Hungary, while delays can be observed in the case of transport work of Belgium, Austria and Denmark. The comparison results in the case of the Czech Republic do not seem to be stable enough and were not quoted for this reason.

Conclusions

The studies of the PZ position of cyclical fluctuations play a significant role in the creation, verification, or calibration of business cycle models as well as in the forecasting process. By their nature, they also play a fundamental role in the construction of leading or possibly parallel business climate indicators.

The evaluation of the degree of synchronization of fluctuations is one of the basic of all these analyzes. The presented results (confirmed also by estimations of the maxima of spectral density functions) show that cyclic fluctuations in transport performance do not differ in their characteristics from the typical ranges observed in other branches of the economy. However, when it comes to the degree of synchronization of cyclical fluctuations in transport performance in different countries, it can be described as moderate. This is evidenced by the values of both similarity indicators. Also, phase shifts estimated on the basis of spectral analysis do not seem (so far?) To provide a clear description that could be – without much fluctuation – cited in the context of "empirical evidence" of strong synchronization. The length of the time series, including the number of quarterly data for Poland, additionally require treating the results with a proper dose of caution.

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FORECASTING THE INFLUENCE OF TRAFFIC DEMAND ELASTICITY ON THE EFFECTIVENESS OF ROAD INVESTMENTS – ANALYSIS RESULTS FOR THE KRAKOW CITY RING ROAD SYSTEM

Abstract

The paper is devoted to simulation analysis of the phenomenon often observed in contemporary urban areas, i.e. the so-called induced traffic resulting from the improvement of travel conditions in the road network. On the basis of analyzes carried out in the simulation model of Krakow, it was shown, as exemplified by the postulated changes in the urban peripheral system of Krakow – i.e. the construction of the western section of the so-called 3rd city ring road and further narrowing of the so-called 2nd city ring road – the appearance of additional car traffic may affect the output image of the city's transport system. Taking into account the elasticity of road demand has a significant impact on the resultant parameters of the network operation and can significantly change the final assessment of the effectiveness of a given road investment – and also provide important premises for a long-term strategy of shaping the city road system.

Keywords: induced traffic, demand elasticity, Krakow, macrosimulation model

Introduction

A commonly observed phenomenon in modern cities is the fact that efforts and actions taken to expand the supply of the transport system are not able to keep up with the constantly increasing transport demand. Despite multi-million investment expenditures in the development of the road network (i.e. supply), these profits are in the long run significantly or completely "consumed" by the constantly increasing traffic (i.e. demand), which leads to the exhaustion

of capacity of the system – and consequently, the deterioration in the efficiency of its functioning, measured, for example, by time or speed of travel.

This phenomenon is well known in the theory and practice of road transport systems as so-called induced traffic which – apart from demographic and economic factors – may be caused by the improvement and development of road infrastructure itself. Initial improvement of traffic conditions in the network, resulting from the widening of roads, construction of multi-level junctions etc., encourages increased transport activity and results in increased traffic on the network. In urban conditions, where the transport system often operates in a state of near saturation, even a small increase in traffic may lead to the limit of capacity being exhausted in critical parts of the road network – and this in turn to an increase in congestion and a significant decrease in travel speed in a wider area of the city (or speaking colloquially, to an even worse traffic jams in the city). It leads to a paradox in which investment activities bring only a short-term improvement of travel conditions, and in the long run can be counterproductive, bringing a significantly (or completely) different effect from the intended one (this is known in transport economics as the so-called Lewis-Mogridge law).

Therefore, it is necessary to use analytical methods and tools that will describe and forecast processes occurring in transport systems of modern cities – e.g. simulation models that predict the distribution of travel flows in the network and provide information on the expected performance and functioning of the transport system. According to the Blue Book developed by JASPERS, simulation models are the basic and key tool in traffic analysis and forecasts, and should be used to evaluate any investment projects that could bring about fundamental changes in the road network. The obtained simulation results – travel flows in the network, their parameters related to distance and travel times (vehicle-km and vehicle-h), average speed, etc. – are the basis for further assessment of economic and financial efficiency and indicators calculated under the analyzes of costs and benefits. Taking into account the variability of the state of demand depending on the state of supply can therefore significantly change the final assessment of a given road project and decide on its final (in) effectiveness.

This article presents the results of analyzes in the model of the Krakow transport system, carried out using macro-simulation methods and tools. The aim of the work is to show – on the example of postulated changes in the urban road system of Krakow (western sections of the so-called 2nd and 3rd city ring roads) – differences in the results of road investment analyzes that arise due to the phenomenon of potential elasticity of demand (i.e. road inducement or suppression) depending on traffic conditions in the road network.

1. Elasticity of road demand as a measure of the phenomenon of the induced traffic

In describing the phenomena of the induced (or suppressed) movement, caused by the improvement (or deterioration) of traveling conditions in the network,

an analogy is used to the law of supply and demand, i.e. the classical dependence in the world of economics. The level of travel demand is not a constant value, but it reacts depending on the so-called general travel costs in the network, and this relationship can be presented in the form of a curve describing the elasticity of road demand as a function of costs on the supply (road) network. This parameter is defined as the quotient between the difference in traffic intensity (i.e. the number of vehicles or vehicle-kilometers in a given unit of time) to the difference in the measure of traffic conditions (i.e. change of travel times, level of freedom of movement, etc.) – i.e. as a difference between the values after and before the implementation of the road investment. The demand elasticity rate can be represented by the equation (1), which is a description of this relation that can be used in simulation models:

$$\varepsilon_{ij}^{W_x} = \frac{\left(\frac{d_{ij}^{W_x} - d_{ij}^{W_0}}{d_{ij}^{W_0}} \right)}{-\left(\frac{t_{a,ij}^{W_x} - t_{a,ij}^{W_0}}{t_{a,ij}^{W_0}} \right)}, \tag{1}$$

where:
$\varepsilon_{ij}^{w_x}$ – demand elasticity rate [–] for investment project (variant) Wx,
d_{ij}^{Wx}, d_{ij}^{W0} – number of vehicles [vehicles/hour] traveling from the traffic zone i and to the traffic zone j, respectively in: in the investment variant Wx and in the non-investment variant W_0,
$t_{a,ij}^{Wx}$, $t_{a,ij}^{W0}$ – car travel times (actual) in the network [min] from the traffic zone I and to the traffic zone j, respectively in the investment variant Wx and in the non-investment variant W_0.

According to the above equation, the decrease in the cost of travel in the network – i.e. reduction of travel times – will result in a positive change in the number of vehicles between the given regions (the induced traffic); while the increase in travel costs – i.e. increasing travel times – will mean a negative change in the number of vehicles (the suppressed traffic).

The phenomenon of the induced traffic in the short time horizon (up to several years) results from changes of travel routes in the network (taking over traffic from other routes), changes in the means of travel (taking over traffic from public transport) and changes in travel time (e.g. taking over traffic from other times of the day). In the long-term, changes resulting in the induced traffic are shaped additionally by factors such as changes in sources and destinations and changes in the level of mobility (i.e. average number of trips) – which result from long-term demographic and economic changes initiated by the development of road infrastructure (e.g. changes in spatial development). A review of scientific and research literature indicates that the demand elasticity rate can be estimated at roughly 0.3–0.8 in short-term terms, and to 1.0–1.2 in long-term terms[1]; in simulation analyzes it is recommended to use values of the order of 0.5–0.8 to describe the effects of short-term phenomenon of the induced traffic[2]. These values can also refer

[1] A. Szarata, *Modelowanie podróży wzbudzonych oraz tłumionych zmianą stanu infrastruktury transportowej*, Monograph, Cracow University of Technology, Cracow 2013.

[2] T. Litman, *Generated traffic and induced travel. Implications for Transport Planning*, Victoria Transport Policy Institute, 2017.

not only to the number of journeys, but also to the measure of operation performed by all vehicles in the road network – that is, the product of the so-called vehicle-kilometers (or vehicle-miles).

Taking into account the elasticity of road demand is of fundamental importance for assessing the effectiveness of road investments. In many research works, it is emphasized that analyzes conducted on the assumption of a rigid level of road demand tend to overestimate the benefits of road projects, and even small changes in the volume of demand (several percent) can have a very large impact on the results of the final cost-benefit analysis. This is due to the fact that the induced traffic causes a further increase in travel costs for all users in the road network, which has already achieved a fairly high level of saturation – and it brings relatively small benefits, as the induced traffic mainly concerns optional journeys. As experience and planning practice shows, depending on network conditions and volume of traffic, taking into account the elasticity of demand at the level of 0.5 – i.e. value, which is supported by many empirical observations – may lead not only to a significant reduction of estimated profits from the investment project, but in some cases change the result of the final efficiency analysis to negative[3].

2. Methodology and assumptions of analyzes – Krakow transport system model

For further analytical works, showing what differences may appear in the assessment of a given road project as a result of taking into account the demand elasticity factor, a simulation transport model Krakow created with the aid of the PTV VISUM software will be used. This model is a macroscopic representation of the transport system in the area of the city of Krakow and neighboring municipalities (the area of the Krakow agglomeration) and was created as part of the Comprehensive Traffic Research carried out in Krakow in 2013.

The simulation analysis will be carried out for two variants regarding the transformation of the city's perimeter system in Krakow, and more specifically – in the western part of the city. According to the strategic intentions, the target peripheral system of Krakow is to consist of four bypass roads, each of which is to play a different function depending on the importance and location in the network, adopted design solutions, the share of local and long-distance traffic, etc.

Among the intentions and postulates related to the city's peripheral system of Krakow, there are two projects of key importance for the functioning of the transport system in the whole city:

– Construction of the western section of the so-called 3rd city ring road, i.e.: Zwierzyniecka route, Pychowicka route and Lagiewnicka route (ZPL route) – in the GP road class with a section of 2 × 2 or 2 × 3 (between nodes). In the future, the 3rd city ring road will be the basic communication frame (axis) for car trips within the city, ensuring efficient perimeter linkage of large Krakow settlements and outgoing traffic from downtown areas;

[3] D. Coombe, *Induced traffic: what do transportation models tell us?*, Transportation 1996, 23.

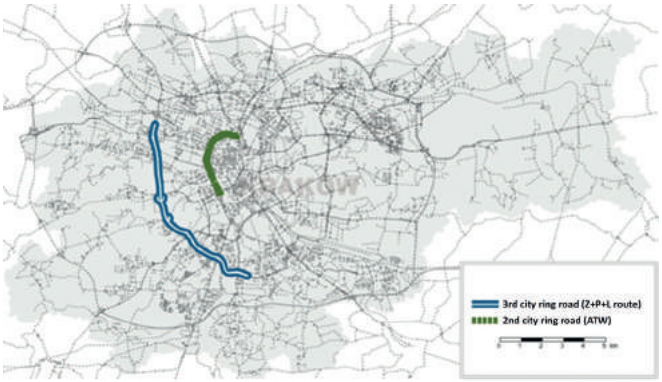


Figure 1. Analyzed investment projects – western sections of the so-called 3rd and 2nd Krakow city ring roads
Source: own elaboration based on: Krakow's Movement Model

– Narrowing of the western section of the so-called 2nd city ring road, i.e. the route of Aleja Trzech Wieszczow (ATW), and potentially also the Debnicki Bridge and al. Konopnicka – degradation to the class Z road and leaving one lane for car traffic in each direction. In the present state, the 2nd city ring road, running in the city center of Krakow, must carry significant flows of local and long-distance traffic, which due to the lack of alternative connections (e.g. the 3rd city ring road) must pass through the center of Krakow.

These are complementary and related projects, and at the same time their implementation will lead to a fundamental change in travel conditions across the entire transport network of Krakow. Therefore, it is necessary to forecast their potential effects in the context of the induced traffic, which may adversely affect the expected improvement in the conditions of car travel. It will also help to answer the question of the direction in which the Krakow road system should be shaped in order to obtain more tangible results.

The simulation analysis of the above projects was carried out for the forecasting model 2025 at the morning rush hour (7:30–8:30). The following simulation scenarios (variants) were assumed in the works:

– W_0 non-investment option for 2025;
– W_1 investment option for 2025, in which the western section of the third beltway was implemented – Zwierzyniecka route, Pychowicka and Lagiewnicka;
– W_2 investment option for 2025, i.e. variant W1 extended additionally with narrowing of the western section of the 2nd ring road – on the section from Rondo Grunwaldzki to the node with ul. Wit Stwosz – up to 1 lane in each direction (for general traffic).

For comparison, works in variants W_1 and W_2 were carried out with the assumption of a rigid level of demand – i.e. the number of motor vehicles (in each travel relation in Krakow) the same as in the W_0 variant, and taking into account the elasticity of demand – i.e. the number of motor vehicles in variant W_1 and W_2, which varies depending on travel times in the network loaded according to equation (1), with a coefficient $\varepsilon_{ij}^{w_x}$ of 0.50 or 0.75.

3. Results of simulation analyzes – effects of induced traffic

Table 1 presents the result parameters obtained for individual simulation scenarios. Figure 2 is a graphical representation of the phenomenon of the induced traffic according to simulation analyzes in the Krakow road network, obtained by overlapping simulation results in investment variants with rigid ($\varepsilon_{ij}^{w_x} = 0$) and flexible ($\varepsilon_{ij}^{w_x} = 0.50$ or 0.75) number of car trips. In other words, the travel streams visible on it can be interpreted as a potential underestimation of the traffic volume in the case when investment variants (W_1, W_2) are set to a fixed (rigid) level of road demand.

Table 1. Simulation results – parameters of the road network functioning in the scale of the entire model area

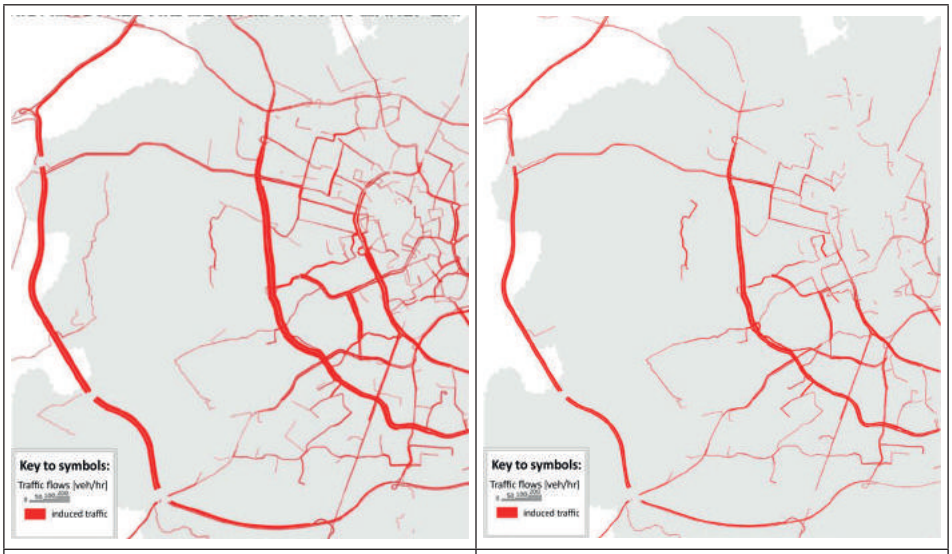
Variant 2025	Demand elasticity rate	Number of trips – total	Number of trips – induced traffic	Operating parameters of the road network		Erosion of the initial reductionin [hr] by the induced traffic	Average speed
		[vehicle/ hour]	Δ [vehicle/ hour]	[vehicle-km]	[vehicle-hour]	Δ [vehicle-hour] [%]	[km/hour]
W_0	–	78 673	–	958 997	20 159	–	47.6
W_1 (ZPL route)	0	78 673	–	950 245	19 155	–	49.6
	0.50	80 048	+1 375	968 359	19 757	+602 (60%)	49.0
	0.75	80 736	+2 063	977 408	20 071	+916 (91%)	48.7
W_2 (ZPL route, ATW narrowing)	0	78 673	–	956 232	19 550	–	48.9
	0.50	79 432	+759	967 279	19 911	+361 (59%)	48.6
	0.75	79 811	+1 138	972 791	20 098	+548 (90%)	48.4

Source: own elaboration

For both investment variants (W_1 and W_2), the analysis conducted on the assumption of a rigid level of road demand shows that the implementation of the assumed scenarios brings a clear improvement: the new route (ZPL route) takes over a significant number of vehicles from the wider area of the city, especially parallel sections of the 4th city ring road (A4 motorway) and 2nd city ring road (ATW) – and the traffic in the section of the ZPL route in both variants ranges in the order of 3500–4000 vehicles/hour. There is also visible the effect of changes on the 2nd city ring road (ATW), where the traffic decreases only slightly in variant W_1 (about 3600 vehicles/hour in the cross section of Debnicki Bridge), but clearly decreases as a result of the narrowing of the route in option W_2 (around 2200 vehicles/hour). The implementation of the investment brings clear changes in travel parameters across the entire network: the time spent by all vehicles in the network decreases by 500 (W_2) to 1.000 (W_1) vehicle-hours, and the average speed of travel increases to 48.9 km/h (W_2) and even 49.6 km/h (W_1).

Taking into account the elasticity of road demand, to a large extent, changes the image of the analysis results obtained. In option W_1, the construction of the ZPL

route without any further interference in the road system initially brings a marked reduction in travel times in many relations in the city, which results in increased traffic in the wider Krakow area. Figure 2 shows how the induced traffic is not concentrated only along the ODG route itself (additional 300–400 vehicles/hour in cross-section), but also appears on other sections of the network – i.e. both access roads and parallel connections, i.e. 4th and 2nd city ring roads. Depending on the adopted elasticity of demand, this means the appearance of an additional 1400–2100 vehicles in the network, and the average speed of travel in the network is lower by approx. 0.5–1.0 km/h than in the variant of rigid road demand.



variant W_1 (ZPL route) | variant W_2 (ZPL route, ATW narrowing)

Figure 2. Simulation results – a graphical representation of traffic flows induced in the Krakow's road network
Source: own elaboration based on: Krakow transport system model

In option W_2, the construction of the ZPL route along with the ATW constriction also means (initially) positive changes in travel times in the network, but the scale of induced traffic is clearly lower than in the variant W_1. Induced traffic appears mainly along the 3rd city ring road (additional 200–250 vehicles/hour in section) and 4th city ring road, but it virtually completely disappears on the narrowed section of the 2nd city ring road. You can also see the limitation of the network effect – the induced traffic appears mainly in the southern part of Krakow, but it is only visible to a small extent in the central (and northern) area of Krakow. The demand elasticity results in the appearance of an additional around 700–1100 vehicles in the network, and the fall in the average speed compared to the rigid demand variant is only about 0.2–0.5 km/h.

Conclusions

The results of the above analyzes show how important in the assessment of the effectiveness of road projects in cities may be the lack of taking into account the reaction (elasticity) on the side of road demand for the initial improvement of network traffic conditions. In the analyzed variants of W_1 and W_2, the elasticity of demand at the level of 0.50–0.75 means that the initially estimated reduction of time spent by all vehicles in the network, i.e. the number of vehicle-hours, can be lower by as much as 60–90%; There is also a clear increase in network loading, i.e. the number of vehicle-kilometers. Taking into account changes in these parameters must therefore be important for further analysis of costs and benefits, which in turn will affect the final assessment of economic and financial efficiency.

The conclusions for the long-term strategy of shaping the Krakow road system are also important. It can be seen that the results of the variant W_1 reflect the paradox often observed in modern cities: the implementation of the western section of the 3rd city ring road without further interference in the road system will not result in the planned relieve of 2nd or 4th city ring roads, where the released capacity reserves can be quickly "filled" by increased traffic car. In option W_2, further narrowing of the 2nd city ring road will not only significantly reduce the car traffic along the ATW corridor, but will also reduce the scale of traffic induction in the area of the city center of Krakow.

A step-wise transformation of the Krakow road system according to the W_2 variant, i.e. construction of the 3rd city ring road and further narrowing of the 2nd city ring road, seems to be the optimal variant – allowing on the one hand the improvement of accessibility and speed (times) of travel in many travels in the area of Krakow; on the other hand – durable reduction in traffic load, especially in the city center.

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SELECTED SAFETY PROBLEMS OF AUTONOMOUS VEHICLES

Abstract

Autonomous cars are a fast-growing technology that was considered science fiction a few years ago. Particularly in such a dynamic context of changes, some ideas about this technology may be wrong, and concerns related to its development, impact on the environment and the nature of the innovation process are misleading. The article criticizes the view that autonomous vehicles must overcome hundreds of millions of kilometers so that they can be considered safe enough to allow them to move on public roads. The doubts discussed concern the highest, fifth stage of automation of autonomous vehicles.

Keywords: autonomous vehicle, mobility, automation

Introduction

An autonomous transport system can be defined as a system in which the driver of the means of transport – by plane, by train, by ship, by bus or by car – is replaced by a technologically advanced control system consisting of software, computers, sensors, communication devices etc., located in the vehicle itself, as well as in the infrastructure used by the vehicle, enabling safe and efficient movement of vehicles on particular routes[1]. Currently operating transport systems differ in the degree of automation. Automation of transport entails changes in many areas beyond the transport system, causing the development of physical and digital business environment, involvement and education of users, challenging many existing aspects of the functioning of modern societies, ranging from cultural behavior

[1] B. Grucza, *Wizje i scenariusze rozwoju autonomicznych systemów transportowych* [in:] *E-mobilność: wizje i scenariusze rozwoju*, eds. J. Gajewski, W. Paprocki, J. Pieriegud, Publication of the European Financial Congress, Sopot 2017, p. 63.

patterns of drivers and passengers to redefining the concept of ownership of vehicles. Among the existing branches of transport, a particularly dynamic development of these systems can be observed in relation to road transport, including in particular individual motorization. Autonomous cars are a fast-growing technology that was considered science fiction a few years ago. Particularly in such a dynamic context of changes, some ideas about this technology may be wrong, and concerns related to its development, impact on the environment and the nature of the innovation process are misleading. On the basis of literature research, an attempt was made to identify the key problems related to vehicle safety of the fifth level of automation and to verify some of the concerns raised related to their admission to traffic on public roads.

1. Degrees of vehicle automation

The Society of Automotive Engineers (SAE) distinguishes five levels of vehicle automation[2]. At levels 1 and 2, the vehicle is still man-driven and solutions such as adaptive cruise control, responsive braking and a parking assistant help him. At level 3, the car is on an "autopilot", but a person can take over if necessary. Level 4 requires the driver even less, allowing him to even take a nap, while at level 5, where the car is fully automated, the vehicle may not even be a driver's seat or controls.

An inspiring analysis of the most common misunderstandings regarding autonomous vehicles was made in the article by A. Hars[3] from the German technology company Inventivio, focusing on a fully automated driving method (L5).

2. Impact of the distance covered on the safety of autonomous vehicles

The issue of the safety of autonomous vehicles is often reduced to the simple use of statistics and leads to the conclusion that "fully autonomous vehicles must travel hundreds of thousands of kilometers and sometimes hundreds of millions of kilometers to demonstrate their reliability[4]". According to A. Hars[5], similar conclusions are in the long run unsustainable because the statistical argument is often based on false assumptions. The basic problem concerns the estimation of the accident rate, where the identified accidents involving autonomous cars are compared directly with accident rates involving drivers – people. The probability of failure, i.e. the estimate that the fatal accident will occur at a certain distance is very low, and the reverse the success rate, the probability that no death toll

[2] *Connected and Autonomous Vehicles – The UK Economic Opportunity*, KPMG and SMMT, March 2015, p. 5.

[3] A. Hars, *Top misconceptions of autonomous cars and self-driving vehicles*, Thinking outside the box: Inventivio Innovation Briefs Issue 2016-09 (Version 1.3).

[4] J.M. Anderson, N. Kalra, K.D. Stanley, P. Sorensen, C. Samaras, O.A. Oluwatola, *Autonomous Vehicle Technology. A Guide for Policymakers*, RAND Corporation, Santa Monica, Calif 2016.

[5] A. Hars, *Top misconceptions…*, p. 6.

will occur at a certain distance is very high. When observing autonomous cars, you can get estimates of the probability of failure. The belief that such estimates reflect the real accident rate increases with the number of kilometers traveled by these vehicles. However, the change in the assumed level of confidence causes that the number of kilometers traveled allows to recognize that self-driving cars are as safe as vehicles with drivers ranges from several dozen million kilometers to even several billion kilometers driven.

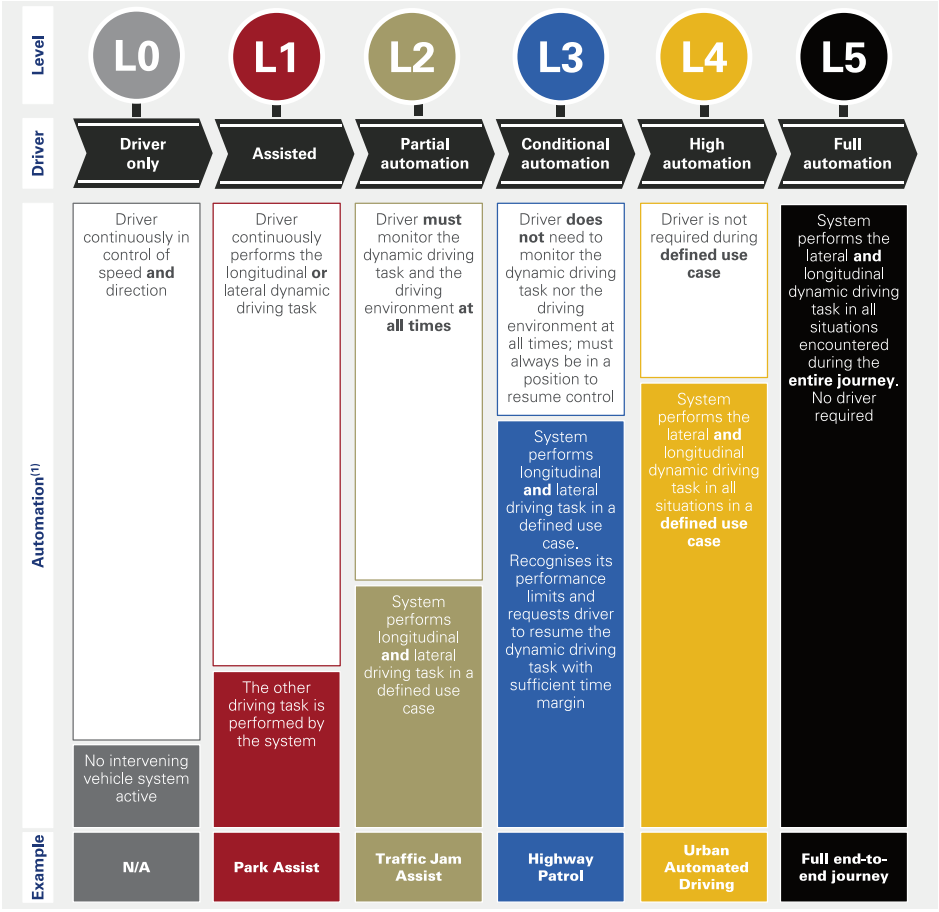

Figure 1. Degrees of vehicle automation
Source: *Connected and Autonomous Vehicles – The UK Economic Opportunity*, KPMG and SMMT, March 2015, p. 6

3. The rate of fatal accidents and the safety of autonomous vehicles

To obtain a safety index of autonomous vehicles, the number of fatalities is often divided by the number of miles traveled, which increases the death rate because a single accident can lead to many fatalities and the number of fatal accidents may

depend on many factors other than driver reliability. The RAND report indicates that many accidents that do not involve fatalities are not recorded. The ratio of the actual number of accidents to the number reported is not clear. Some studies suggest that it may be as low as 2–4 to 1. If you take into account different types of accidents, and not only accidents with fatalities, then the number of kilometers that must be overcome by autonomous vehicles to be considered safe, falls significantly. The probability distributions of fatalities, accidents with injuries and other accidents are in fact correlated. A car that is much better at avoiding fatal accidents than a human driver is probably also better at avoiding other accidents.

4. Time of moving autonomous vehicles as an indicator of safety

The most effective way to obtain a large number of "test" kilometers in autonomous traffic is driving on closed test tracks under controlled conditions and moving on highways. Driving a car on the highway is generally safer than driving on many other types of roads. Since the average vehicle speed varies depending on the type of road, the total autonomous vehicle movement time may be a better basis for measuring the accident rate than the distance covered. The autonomous urban environment, with a large share of pedestrians and cyclists, may cause particular difficulties[6]. This can be more evident in the statistics of accidents than in the mortality reports, because the average speeds are lower. Time devoted to the movement of autonomous vehicles in urban conditions could be a more accurate indicator of their safety level than the number of kilometers driven[7].

5. Comparing the algorithms of autonomous vehicles to human behavior

The problem of measuring the safety of autonomous vehicles is often related to the adoption of an appropriate reference point and defining detailed ranges of constituent elements understood as safety to be monitored[8]. In the case of self-driving cars, there is no standard developed in this respect[9]. The reference of accident statistics of autonomous vehicles to data concerning people-drivers should not be used as a basis for assessing their safety. These cars, which never tire, do not drink, do not divert attention from the road[10] – they would have to commit other serious errors on a much larger scale than people to get similar levels of accident. Of course, this is unacceptable. Rather, the expectations and requirements

[6] *Driving to the future. The development of connected cars*, The Economist Intelligence Unit Limited 2016, p. 18.

[7] A. Hars, *Top misconceptions…*, p. 7.

[8] D.A. Brown, G. Cooper, I. Gilvarry, A. Rajan, A. Tatourian, R. Venugopalan, D. Wheeler, M. Zhao, *Automotive Security Best Practices*, Intel Security, Santa Clara 2016, p. 4.

[9] E. Heymann, J. Meister, *The digital car More revenue, more competition, more cooperation*, Deutsche Bank Research, 03.07.2017, p. 20.

[10] *Driving to the future. The development…*, p. 7.

regarding the level of safety that autonomous cars should present based on what is known about the problems and risks of driving vehicles in general and not only about the specificity of running them by people should rather be specified. The need to develop detailed risk models for driving vehicles that use accident statistics and determine the impact of road structure, load levels, weather, and many other factors affecting the driving risk that could be used to create reference data for the preservation of autonomous vehicles. These can be, for example, mileage divided by road type. According to A. Hars[11], it is possible to publish a complexity indicator that points the average complexity of the environment in which the vehicles moved or the overall distribution of the complexity of environments encountered during testing.

6. Increasing reliability of autonomous vehicles and its impact on safety

In contrast to the error rate of drivers of classic cars, the reliability of an autonomous vehicle cannot be considered constant. It improves over time, because due to the "cross-linking" of autonomous cars, a possible software error occurring in all copies of a given car model can, after being detected in one of them, be removed from all cars. The future mobile system will require the creation of an IT system to manage vehicle traffic and network. Such a system will help in the management and control of the movement of autonomous vehicles and fleets intended for the provision of shared mobile services[12], thus it will create completely different possibilities of caring for the safety of individual vehicles and their users. In contrast to the production of goods in which batches are tested to detect design and production problems, it is possible to remove the defect not only in products passing through the production process in the future, but also in batches that have already been released to the market. Developers will improve their algorithms to solve the problem in all cars on the road: the accident rate of a given car model will no longer be the same. The simple statistical model does not take into account the feedback loop, which tends to reduce the accident rate at each incident encountered. On the other hand, when an accident occurs, it may increase the estimated accident rate above the accepted level and determine that the car model is not suitable for public use. All cars can be immediately withdrawn and thus prevent further accidents. This is a completely different approach than in the case of other physical products, in which the detected defect after passing such products to the consumer may be difficult to remove. Since people driving cars also cause accidents, it is worth avoiding two cases: recognizing cars as safe and allowing them to move, although they are not yet safe enough and recognizing cars as dangerous and preventing them from moving despite being safe. In the first case, self-propelled vehicles will cause damage because people using them will use them. In the second case, the damage will be suffered because people who could use an autonomous

[11] A. Hars, *Top misconceptions…*, p. 8.

[12] S. Corwin, J. Vitale, E. Kelly, E. Cathles, *The future of mobility. W jaki sposób techniki transportowe i trendy społeczne tworzą nowe ekosystemy gospodarcze*, Deloitte University Press, 2015, p. 16.

vehicle run alone. This seems particularly important when we take into account the observed increase in the developed countries, the number of accidents caused by the deconcentration of drivers using smartphones while driving[13].

7. Luck and critical situations

Luck can play a huge role in human driving and have a significant impact on the perception of the safety of autonomous cars. The fact that the accident does not happen to the driver, may not have much to do with his high skills, but a lot with the relatively low frequency of difficult, unexpected situations on the road. From the perspective of autonomous vehicles, this means the need for more sophisticated driving risk models[14]. Accidents form the basis of official statistics, but accidents are only the tip of an iceberg, they are the result of critical situations in terms of security that have not been avoided. Driving behaviors combined with external factors such as poor road conditions, technical defects, obstacles etc. lead to critical situations for safety. Fortunately, most of these critical security situations do not lead to accidents. In more than 93% of accidents, driver behavior is the leading factor in mortality. But this also highlights the important difference between drivers and autonomous vehicles. Based on human behavior, we focus on accidents. Thanks to autonomous vehicles, attention is focused on critical situations for safety. Every small mistake of an autonomous car is cataloged and evaluated long before any accident. When the driver moves slightly off the road, no one is interested unless an accident occurs. However, when the self-propelled car improperly sticks to the traffic lane, it is rightly regarded as its significant drawback. The same happens when the autonomous car does not give way to other vehicles etc. Therefore, you should not use accident statistics to compare the reliability of drivers and autonomous vehicles, it is worth comparing the behavior of the driver and the impact on the frequency of inducing critical situations. It is easy to measure in a stand-alone car, but it requires more effort for the driver. Although no system is fully reliable, an autonomous vehicle can potentially provide unprecedented levels of transparency in the event of accidents[15]. Rather than relying on the testimony of the driver or eyewitnesses of the incident, the autonomous vehicle will have a wide range of data on conditions before, during and after the accident, which can be used for evidential purposes, but also for teaching other autonomous vehicles, identifying what went wrong and giving a chance to avoid similar situations in the future.

[13] *Future of the vehicle*, BlackRock Investment Institute 2017, p. 5.
[14] A. Hars, *Top misconceptions…*, p. 9.
[15] *The Autonomous Vehicle Revolution: Fostering Innovation With Smart Regulation*, Center for the Study of the Presidency and Congress, Washington, March 2017, p. 4.

Conclusions

The view that autonomous cars must travel hundreds of millions of kilometers to be considered safe seems unjustified. It is misleading to focus only on death rates as a result of moving autonomous vehicles, while many other correlated reliability measures are available that are more adequate and easier to measure. It seems inappropriate to focus primarily on accidents – you should focus on avoiding situations critical to security. The human intuition associated with the driver's own abilities and behaviors can be misleading. Luck may be more important in the safety balance than it often seems. It is also worth realizing that the reliability of an autonomous car changes over time and that the potential of accidents and damage resulting from the functioning of autonomous vehicles after their introduction for public use may turn out to be much smaller than in the case of defects of other traditional products and devices. It is worth paying attention to two sides of the coin – it is necessary to avoid not only moving a vehicle that has been allowed to move on public roads too early, but because an alternative human ride is not safe at all, there is a real risk that autonomous cars will be too late admitted to public traffic, which will also lead to many road accidents that could be avoided.

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TRANSPORT CONDITIONS OF THE GLOBAL ECONOMY

Abstract

The subject of research is the global economy perceived through the prism of its conditions and transport challenges that its development is currently generating. The author justifies the hypothesis that transport being a lever of globalization processes and a stimulator of the development of the global economy requires improvement, and in all dimensions of its activity on an international scale. For this purpose, basic barriers and threats of transport and logistics that are or may appear in the global economy in the near future were identified. The potential effects resulting from this reason for the global economy and its selected sectors, mainly trade were also indicated. It also identifies actions that should be taken to eliminate or reduce existing transport barriers, including mainly infrastructure barriers, which should lead to an increase in the efficiency and effectiveness of the transport sector on a global scale. The publication uses the studies and reports of international organizations such as the WTO, WB, WEF regarding the subject under study. The obtained research results allowed to formulate conclusions that, firstly, the transport infrastructure and low quality of transport services are still a significant barrier to the development of many economies – including the world's leading ones – and, secondly, that it is necessary to undertake coherent, internationally coordinated stimulating activities for transport development on a global scale. Transport is becoming a factor determining further growth of competitiveness and ensuring the expected level of facilitation in world trade and the required efficiency of functioning of global supply chains.

Keywords: global economy, global supply chains, global transport challenges, global logistics performance, transport and logistics indices

Introduction

The development of the global economy, stimulated by the dynamics of globalization processes and the liberalization of all kinds of markets, and above all goods and capital, and the implementation of a new paradigm of stable and sustainable development of the regulatory model for this mega economic system, generates a number of transport and logistics challenges. They have a different character and distribution in time and their sources lie in both the real and regulatory sphere of the global economy, whose development directly affects the global transport sector, while shaping the global TSL sector. There are no full, in-depth research of this issue, and available studies, in addition to reports from international organizations such as the WTO, OECD, IMF, WEF, WB, etc., are partial, making it impossible to cover the subject in a comprehensive manner. For this reason, this article attempts – to the extent that is possible in this type of study – to identify these challenges, treating them both in terms of opportunities, as well as barriers and threats of a transport nature. At the same time, the effects that arise or potentially may arise from this for the global economy as well as its leading sectors, which transport supports, including mainly trade, limiting the efficiency of functioning and the effectiveness of its development are indicated. The categories of efficiency and effectiveness of the global economy, based on the transport standard, were determined on the basis of indicators determining the competitiveness of economies and the degree of trade facilitation in international relations. For this purpose, studies and reports of international organizations such as WTO, WB, WEF were used.

In addition to such a defined objective, it was also undertaken to define activities of a regulatory and organizational nature, as well as investment and infrastructure in this area of the global economy, necessary to gradually remove existing gaps and development disproportions in the area of infrastructure and eliminate solutions with discriminatory features. There was formulated the hypothesis that transport, which is an important component of the global TSL sector, constitutes a lever of globalization processes and a stimulus for the development of the global economy, needs improvement – and in all dimensions of its activity on an international scale. The implementation of the adopted objective and verification of the hypothesis required presentation of basic features as well as factors and directions of development of the contemporary global economy and also defining the place and role of transport in the process of its development. The factors were identified and the reasons for the increase in the transport capacity of the world economy were determined.

The results of the research and the conclusions drawn based on them were included in the conclusion, highlighting those that particularly emphasize the role of transport as a factor not only able to provide the required level of facilitation in world trade and high efficiency of the global logistics space, but also with a strong impact on the growth of competitiveness of economies operating in the sphere of international division of labor. In addition, it was pointed out that transport should have more influence than currently has on the creation of logistic and economic order in the global economic space.

1. The development of the global economy and its impact on the transport sector

The global economy is a system of production, technological, commercial, financial and institutional relations existing between national economies of individual countries at different levels of socio-economic development, including them in the global process of production and exchange. This peculiar mega economic system has the ability to function as one, relatively coherent system in real time. The lever of its development is globalization, which leads to a gradual reduction of barriers between countries and the strengthening of trade relations and other economic ties between them. It is stimulated by various factors, among which growing international trade, development of multinational corporations, progressive internationalization of the finance sphere and application in all these areas and spheres of new information and communication technologies, especially computer (ICT) are of fundamental importance[1].

The processes of globalization, which in the system of the world economy take place with different dynamics, affect with greater or lesser force not only the sphere of trade in goods, but also the remaining spheres. In addition to global trade, one of them, the most affected by this impact, is transport that supports global trade. The two most internationalized, operating in the intercontinental scale transport branches, i.e. air and sea transport, play a special role in the transport of world trade commodity mass in terms of value. The share of both of these transport branches in servicing global trade, measured in monetary units (15.5 bn US $ in 2016) was 76% and 12.5% respectively[2].

Sea transport – due to its technical and operational properties (mainly mass) and economic characteristics (cheapness) – also plays a special role in servicing the dynamically growing volume of world trade, ensuring efficient, effective and safe transport of successively increasing commodity mass in oceanic transports. In the years 1974–2014, the average annual growth rate of transport in sea trade was 3.0%, and in 2015–2016 2.2%. In subsequent years, i.e. in 2017–2022, a further increase in transport by sea is assumed, an average of 3.2% annually[3].

Global transport of cargo by sea in 2014 exceeded 10 billion tons for the first time in the history of sea transport development, reaching in 2016 the level of 10.3 billion tons, which means that about 81% of the volume of world trade was displaced by sea (the so-called sea trade). With an average transport distance of 1 ton of 5.000 Mm sea transport, if you measure its involvement in transport units (ton-mils), it therefore serves about 92% of world trade in goods[4]. Mutual relations between the growth of global and sea trade, as well as global GDP and industrial production, analyzed over the last 40 years, indicate that there is a clear correlation between the development

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1 S. Chopra, P. Meidel, *Supply chain management. Strategy, planning and*, fourth ed., Pearson, New York, p. 67–69 and 117.

2 *International Trade Statistics*, World Trade Organization, Geneva 2017.

3 *Review of maritime transport 2017. Report by the UNCTAD Secretariat*, Geneva 2017, p. 3.

4 A.S. Grzelakowski, *Globalizacja i jej wpływ na gospodarkę światową i sektor transportu morskiego. Jej implikacje dla Polski i polskich portów morskich,* Bulletin of the Polish Chamber of Forwarding and Logistics 2015, 10–12; *Review of maritime transport 2017*…, p. 3–4.

of trade and maritime transport on a global scale and the rate of economic growth measured by the dynamics of GDP growth[5]. These relationships, defined in the long period of time, provide the basis for stating that marine transport markets (freight markets) are also strongly integrated with global commodity markets spread in the system of developing global chains and supply networks[6].

The analyzed trends and phenomena occurring in the global economy, affecting the global trade and transport sectors, as well as the sphere of functioning and development of global logistics chains and supply networks, were affected by many different factors. The most important of them include[7]:

- dynamic growth of world trade, as a result of liberalization and deregulation of economies and markets, which encounters barriers in the efficiency of handling successively growing streams of goods, characterized by a high degree of spatial concentration;
- extension of the assortment structure of both investment and consumption goods, being a manifestation of changes in the size and structure of global demand and the growing ability to satisfy it on a global scale, including in the transport and logistics sector;
- declining share of mass goods (cargoes), with a low relative unit value in total world trade turnover and growing highly processed goods, with a higher unit value (new products, product innovations);
- price reduction in the long-term – mainly highly processed goods, which is the result of globalization (effects of production scale and increasing openness of markets, etc.), while shortening the life cycle of products;
- intensification of the phenomenon of outsourcing and offshoring on a global scale, which dynamically strongly increases the demand for transport services and, consequently, also forwarding and logistics, while leading to a significant increase in transport intensity;
- significant dynamics of transport markets as markets secondary to commodity markets, which are first subjected to cyclical pressures and structural fluctuations in demand for goods being exchanged on a global scale;
- horizontal and vertical and conglomerate concentration processes with high dynamics in the layout of global transport markets, as a result of strong fluctuations in demand for transport and logistics services;
- pressure to minimize stocks and improve the flow of goods on a global scale, which generates new logistical challenges, involving the need to simplify network structures and reduce transport costs and other components of logistics costs[8];
- the relatively faster growing value of transported products than their quantity, which makes the so-called transport cost sensitivity index of on a global scale; transport costs do not increase in proportion to the increase in the volume

[5] *Ibidem*.

[6] A.S. Grzelakowski, *Container shipping operators as integrators of global logistics supply chains*, Logistics and Transport 2014, 1, p. 49.

[7] A.E. Branch, *Global supply chain management and international logistics*, Routledge Taylor and Francis Group, New York and London 2010, p. 96–98.

[8] J. Mangan, Ch. Lalwani, T. Butcher, *Global logistics and supply chain management*, John Wiley & Sons Ltd., New York 2009, p. 11–12.

of transport, their share in value and, as a result, in the prices of transported goods (transport cost penalty) does not increase;
– increase in efficiency and productivity in transport as a result of product, organizational and marketing-market innovations; these innovations, leading to an increase in productivity in the sphere of transport, affect the sensitivity of transport costs, which triggers the processes of their optimization in the global supply chain;
– (de)regulation of the transport sector on a global scale, which generates not only a number of positive phenomena, such as: increased security and reliability of its operation, reorientation towards sustainable development and reduction of external costs and implementation of innovative solutions corresponding to the challenges of the fourth industrial revolution (automation, digitization), but also serious problems in ensuring the efficiency of world trade flows, as required by global logistics operators.

The factors presented in points 1–11 with varying strength affect the global transport sector, shaping both directly and indirectly both its real and regulatory sphere[9]. The basic processes, trends and phenomena that occur in this area of the global economy should therefore be analyzed and evaluated in the context of changes taking place in its structure and within the global logistic space.

2. Transport as a factor shaping the functioning efficiency and dynamics of the countries' development – research methods and international rankings

The development and effectiveness of the functioning of national economies participating in the international division of labour, including their competitiveness, as well as the efficiency of handling global trade, are determined by many factors. Among them, the factors of transport and logistics are becoming more and more important. The lack of appropriate transport infrastructure, including the network capacity necessary to meet transport needs and its required in terms of current global standards supply chains technical and operational cohesion, as well as low quality of network and transport and logistics services make the economies of countries that are struggling with this type of transport problems, they do not achieve potentially possible economic effects due to their involvement in the sphere of international cooperation. As a result, if transport barriers of this nature occur in countries that are among the leaders in world trade, at the same time affecting the state of the economy and the dynamics of global economy growth, they are becoming serious threats to its development.

This problem is noticed by many countries and global economic organizations such as: World Trade Organization (WTO), World Economic Forum (WEF), World Bank (WB – IBRD) and International Monetary Fund (IMF) and numerous regional groups, including: the European Union, ASEAN and industry associations. Based on the analysis of periodic reports of these organizations, containing precisely

[9] *Transport. Nowe wyzwania*, eds. K. Wojewódzka-Król, E. Załoga, PWN, Warsaw 2016, p. 319–321.

defined sets of measures used to assess the efficiency and effectiveness of the functioning of most countries in the global space and sets of indicators calculated on their basis, it is possible to identify basic factors – including those from transport and logistics groups influencing the studied relations and estimate the strength of their impact on particular spheres of international activity of each of the countries covered by the research.

The most important measures of this type, characterizing both the efficiency and effectiveness of countries in the global economy system, treated as a set of national economies with varying degrees of international connections, include:

– Global Competitiveness Index (GCI), developed by WEF as part of the prepared report (The Global Competitiveness Report)[10];
– Enabling Trade Index (ETI), developed by the Associated with the World Economic Forum Supply Chain & Transport Industry Partnership as part of the prepared report (The Global Enabling Trade Report)[11];
– Logistics Performance Index (LPI), developed by the World Bank[12].

On the basis of these three measures and indicators calculated on this basis, i.e. numerically defined measures of their value, one can assess the level of efficiency and transport and logistics efficiency of each of the countries operating in the global economy system, based on quality standards of infrastructure and transport services. WEF defines competitiveness as an external effect of joint operation of a set of institutional, political and economic factors based on the productivity of economy resources, management efficiency, as well as innovation and efficiency of business operations. The annual reports of WEF on the competitiveness of economies contain a list of synthetic indicators of competitiveness, which are a statistical aggregate calculated on the basis of 114 specific indicators, reflecting the levels of values for each measure, referring to a set of factors (there are a total of 114) determining competitiveness of economies[13]. The level of country's competitiveness is determined by a set of 12 main factors (pillars of competitiveness), among which the pillar: infrastructure is the second most important. In this category of factors collection, the basic importance is attributed to the technical infrastructure of transport and telecommunications and communications. It is stated that they form the main transport and logistics base in each country, determining the level of competitiveness of the economy on a global scale. On the basis of this criterion, the economies of individual countries are ranked, classifying them according to the level of competitiveness of their transport systems.

Transport infrastructure networks and the quality of transport and logistics services affect not only the level of competitiveness of economies, but also the efficient flow of commodity flows on a global scale, which co-determines this competitiveness. The transport infrastructure may facilitate the flow of goods or constitute a significant barrier in their logistics service. Therefore, it determines

[10] *The Global Competitiveness Report 2016–2017. Insight Report*, ed. K. Schwab, The World Economic Forum, Geneva 2017, p. 25; The World Economic Forum and the Global Alliance for Trade Facilitation, Geneva 2017.

[11] *The Global Enabling Trade Report 2016. Insight Report*, The World Economic Forum, Geneva 2017, p. 6–9.

[12] *Trade Logistics in the Global Economy. Logistics performance Index and its Indicators. Connecting to Compete*, The World Bank – IBRD, Washington 2017, p. 7–9.

[13] *The Global Competitiveness Report 2016–2017. Insight Report...*, p. 17.

the efficiency of trade in countries on a global scale. The WTO and WEF reports indicate the basic factors determining the level of benefits that individual countries can derive from participation in the global division of labour. In these reports, using the developed index (ETI), allowing to determine the level of the synthetic index of facilitation in the implementation of international exchange in each country, based on the WTO and WTF standards, which is calculated based on the weighting of individual sub-indices, reflecting the different types of facilitations, also an indicator defining the quality of transport infrastructure. High importance is assigned for determining the synthetic index, recognizing that transport accessibility, the quality of infrastructure and logistics networks in individual countries are more important in creating facilitation and shaping replacement costs than customs tariffs[14].

The indicator defining the level of facilitation in the scope of handling trade in goods from the perspective of transport and logistics conditions consists of a set of 19 balanced partial indicators. They define three main dimensions of the transport factor perceived in the report, i.e. the availability and quality of transport infrastructure (7 partial indexes), availability and quality of transport services, measured by the level of logistics and transport companies competences and timeliness and delivery costs (6 indexes), and the availability and the possibility of using information and telecommunications technologies (ICT – the level of digitization in transport) and the quality of these services (7 indexes).

On the basis of the three above-mentioned indicators, apart from the synthetic ETI index, the ranking of countries is being developed in terms of their transport and logistics efficiency, perceived in terms of its impact on the efficiency of stream of goods service.

In the international system, quantitative and qualitative standards of transport and logistics space of individual countries, which are treated as an important factor affecting the functioning of their economies and indirectly the global economy as well as international trade service, is also assessed using a measure of logistics efficiency (LPI). This measure, which can be expressed in numerical form (index) is a weighted average of the obtained results of the assessment of this efficiency in each country. These results refer to six areas – factors that determine this efficiency, and among them the transport infrastructure and the quality of logistic services are prominent. These include: efficiency (speed, simplicity, predictability) of implementation of border procedures, quality of transport infrastructure essential for servicing international trade, scope of freedom in negotiating and setting competitive prices, quality of logistic services including transport and competences of forms providing these services, and the ability to track shipments in real time, as well as timeliness of deliveries in accordance with the planned or expected date[15].

[14] *The Global Enabling Trade Report 2016. Insight Report...*, p. 12–13.
[15] *Trade Logistics in the Global Economy...*, p. 17.

3. Transport barriers to the increase in the effectiveness of the functioning of national economies and the development of the global economy

Transport infrastructure and quality of transport services as well as the advanced stage of development of modern information and telecommunications technologies in the transport sector – the achieved level of its digitalization, directly defining the digitization of supply chains, as factors shaping the quality of logistics macrosystems are of particular importance for countries with the largest share in world trade. These countries, included in the category of global economy leaders, which thanks to the technologically advanced and innovative economies, gain significant benefits from participation in the international division of labour, do not always have adequate capacity for their position in world trade efficiency and efficiency of their transport and logistics macrosystems. The existing differences in this area and sometimes even a deep asymmetry are perceived by comparing on the basis of the ranking developed by the WTO the position of a particular country in global trade – its share in global exports and imports with the place it obtains in transport efficiency rankings – infrastructure quality transport and network and transport services, as well as broadly understood logistics performance. Such a comparison presenting both the strengths and weaknesses of transport and logistics systems of individual leaders of the global economy, defining also the challenges facing them in this respect, is presented in Table 1.

Table 1. Ranking of countries – the main global engines of global economy growth in terms of their competitiveness as well as transport efficiency and logistics efficiency

Country	HG	GCI	GCI-Inf.	ETI	ETI-Inf.	ETI-JDI	LPI	LPI-Inf.
China	1	28	>50	>50	36	16	28	9
The USA	2	3	11	15	8	8	9	4
Germany	3	5	7	10	6	5	1	1
Japan	4	6	6	13	5	7	10	5
The Netherlands	5	8	4	3	3	9	2	3
France	6	23	8	21	9	4	13	7
South Korea	7	26	17	30	8	7	21	8
Great Britain	8	9	10	6	4	10	4	6
Hong Kong	9	7	1	2	2	3	15	7
Singapore	14	1	2	1	1	2	5	2

Interpretation: HG – global trade position, GCI – Global Competitiveness Index, ETI – Enabling Trade Index, LPI – Logistics Performance Index; GCI-Inf. – assessment of the level of infrastructure development in terms of its impact on the country's competitiveness, ETI-Inf. – condition of transport infrastructure, as a factor determining the level of trade facilitation index, ETI-JDI – quality of transport infrastructure services, LPI-Inf. – transport infrastructure, as a factor determining the level of logistics performance/efficiency of the country.
Source: prepared on the basis of reports: WTO, WEF, WB, UNCTAD, OECD, 2015

Analysis of data contained in Table 1 clearly indicates the disproportions between countries existing on the global scale. These disproportions are particularly visible in the case of China and, to a lesser extent, in South Korea and France. They point to transport barriers real in these countries and, as a consequence, also logistic, which limit the scale of benefits that these countries could potentially benefit from the development of trade and full participation in the international division of labour. As a result, this is reflected in the level of competitiveness of the economies of these countries on global markets.

The Singapore is the absolute, undisputed leader in facilitating trade and the development of high-performance transport and logistics services. Relatively balanced relations in the studied areas occur in Germany, the Netherlands, Hong Kong, Great Britain, Japan and the USA. These countries, with well-developed transport and logistics systems and markets integrated with the commodity market system, not only achieve significant competitive advantages, but also gain the necessary potential to take over the full financial and economic effects of participating in the international division of labour. The elimination of transport barriers, being a long-term process and difficult to implement due to the high capital intensity of such activities and the inability to fully coordinate them on a global scale, is therefore in the interest of every country and the global economy as open, creating greater opportunities for the development of the economic system.

Conclusions

The development of globalization stimulated by the processes of deregulation of economies and the progressive liberalization of commodity and transport markets created new challenges both for domestic transport systems and for the global transport space. This space, in the conditions of popularization of logistic standards for stream of goods flows and the development of global chains and supply networks, was strongly embedded in the logistics macro system of every country and what is particularly important in an open, global logistic space. As a result, real integration of the TSL sector is being carried out, based on the formula of merging its markets with commodity markets. In practice, it significantly facilitates and improves global trade transport services, implemented on the basis of the logistic standards of the flow of commodity flows on a global scale.

These processes, however, do not run smoothly and without collision, because the standards of transport service of the growing world trade flows are still very diverse on a global scale. There are many transport barriers inherent in transport systems in most countries of the world, both in terms of infrastructure, as well as organizational, operational and regulatory, which limit the growth of efficiency and effectiveness of transport operations on a global scale and, consequently, also of the global economy. This is confirmed by the research results obtained.

These results allowed to formulate conclusions that: firstly, transport infrastructure and low quality of transport services are still an important barrier to the development of many economies – including leading countries on a global scale and thus a barrier to global economy development, and secondly, at the current

stage of global economy development. In the era of progressing digitization, it is necessary to undertake coherent, coordinated at the international level investment and regulatory activities stimulating the development of transport on a global scale. Only in this way can you create the basis for building transport order and, consequently, also for logistics in the global economic space.

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ECONOMIC EFFECTS OF ROAD TRANSPORT AUTONOMIZATION

Abstract

Work on fulfilling the dream of self-guiding vehicles began almost 100 years ago. Thanks to the significant progress that has been made in recent years, it can finally be assumed that fully autonomous road vehicles will most likely appear in 10–15 years. It will be necessary to wait much longer for their proliferation, but their economic and social potential is huge. Therefore, the aim of the paper's author is to make a preliminary and for formal reasons also a synthetic review of the economic effects of the road transport autonomization.

Keywords: autonomous vehicles, road transport, external costs of transport

Introduction

In the 1890s, when the first automobile appeared, many people saw in them a miracle cure for all problems of contemporary transport, especially in cities. It seemed that finally serious and expensive problems would disappear, first of all supplying horses with fodder, the need to build and maintain a stable for them, huge amounts of dung found in the streets and sidewalks, and widespread stench. In addition, horse transport was slow and the level of congestion in cities was high.

In fact, all the above problems were solved in a short time, but with the proliferation of cars, new, even more serious and some of the old problems appeared, e.g. congestion returned, only on a much larger scale. Today, once again in history, a huge change in transport is taking place. The model of mobility, widely used in developed countries, is changing, especially the concept of a car and its perception, which is subject to thorough redefinition. The current paradigm of the car as a private and internal combustion means of human-driven transport is heading towards a shared, electric and autonomous vehicle. The vehicle is deprived

of the whole sociological and psychological meaning, i.e. emphasizing the material status of the car owner, or his masculinity, and sometimes also ideology or political preferences (e.g. preferred by Democrats Toyota Prius or Tesla, vs. a republican pick-up e.g. Ford F150 or Dodge RAM).

1. The genesis of autonomous cars and basic concepts

The dream of building autonomous vehicles (AV), i.e. self-guiding vehicles without a driver, appeared already in the 1920s. One of the key reasons for this was the concern for improving traffic safety and reducing the number of fatalities. Today it seems unimaginable, but in the years 1919–1923 in the USA, when the level of motorization even in 1923 did not exceed 120 cars per 1000 inhabitants[1], in road accidents over 60 000 people died (and in the entire decade of the 1920s, over 200 000), which is more than American soldiers in all the battles of the First World War[2].

The first vehicle without a driver was demonstrated on August 5th, 1921 at the air base in Dayton, Ohio. At the same time, it was not a de facto autonomous vehicle but only a remote controlled one. Initially, the control signal was sent via a cable from a car following the vehicle without a driver and later by radio waves. In the following decades, numerous concepts and designs of self-driving cars appeared, new improvements were introduced, such as the now widely known cruise control system – implemented by Chrysler in 1958 and called the "autopilot"[3]. Significant acceleration of works took place from the end of the 1970s, especially in Japan and Germany thanks to Ernst Dickmanns, and then in the USA mainly through Grand Challenge organized by DARPA (Defense Advanced Research Project Agency). It was also influenced by the rapid development and increasingly widespread use of electronic circuits in control systems.

The Society of Automotive Engineers divides vehicles into 6 levels of autonomy. Level 0 are the simplest vehicles in which the driver is not supported by any systems that facilitate driving. On the next four levels from 1 to 4, the role of the driver decreases and finally level 5 means full autonomy. Driving a vehicle on level 5 takes place without the need for any driver interference, thus it is possible to eliminate the steering wheel, pedals, mirrors, etc.

There are currently vehicles that are representing the second level of autonomy. They can park themselves (parallel and perpendicular), stay on a given traffic lane, adjust the speed themselves (e.g. by reading signs of acceptable speed), accelerate and brake, keeping a safe distance from the vehicle ahead etc. Level 3 begins to be available in the most luxury and, at the same time, expensive vehicles, such

[1] https://www.fhwa.dot.gov/ohim/summary95/mv200.pdf (access: 9.03.2018).

[2] P.D. Norton, *Fighting Traffic. The Dawn of the Motor Age in the American City*, The MIT Press, Cambridge 2008, p. 21–22.

[3] F. Kröger, *Automated Driving in Its Social, Historical and Cultural Context* [in:] *Autonomous Driving. Technical, Legal and Social Aspects*, eds. M. Maurer, J.Ch. Gerdes, B. Lenz, H. Winner, Springer Verlag, Berlin 2016, p. 42–56.

as the Audi A8 available from 2019[4]. The car is being driven alone, but the driver must still be on the alert and take over when the system requires it.

Some of the companies claim that levels 2 and 3 are not very secure, because although these cases are rarer, due to the continuous learning of vehicles and their programmers, the vehicle may require driver intervention. It is highly probable that such a reaction will be late, especially when the attention of the driver is focused on reading the newspaper or tracking content on the smartphone and also inferior quality, in which case the driver must drive the vehicle all the time[5]. That is why producers like Waymo and Uber are trying to reach level 4 immediately, i.e. full autonomy in a specific city environment or at the beginning of its part. The exact delimitation of the area of functioning of vehicles on level 4 and on the shared addition allows to better calibrate all vehicle sensors (including lidar) so as to take into account the specific weather conditions of the area and its topography and other characteristics, e.g. a large number of freely moving animals.

The progress in the process of road transport autonomy, which has taken place in recent years, is enormous. Of course, there are still many technical, organizational, legal and mental barriers to overcome, such as the perception of AV by users as uncertain and dangerous[6]. Users will also have to get used to their new exterior appearance as well as the interior of vehicles, because the form and shapes of AV will follow the features they offer. However, the current pace of progress is so great that it can be assumed that fully autonomous cars will appear no more than 10–15 years. According to specialists from IHS Automotive, it will be around 2030. At the same time, they estimate that in the entire world in 2035 the number of autonomous vehicles in operation will be nearly 55 million[7]. This is a small number compared to the total number of road vehicles currently traveling around the world (over 1 billion), however, it should be remembered that most of these vehicles will be shared, and therefore will replace up to 0.5 billion modern private cars and thus will radically change the known us a road transport system[8].

2. Economic effects

Autonomous vehicles move in a harmonic way and at much smaller intervals between them, therefore they make much better use of the available capacity of existing infrastructure than human drivers. It is also assumed that the majority

[4] Ch. Paukert, *Audi says 2019 A8's Level 3 self-driving tech capable of doubling speed*, https://www.cnet.com/roadshow/news/audi-says-2019-a8-level-3-self-driving-tech-capable-of-doubling-speed/ (access: 9.03.2018).

[5] C. Thompson, *New details about the fatal Tesla Autopilot crash reveal the driver's last minutes*, http://www.businessinsider.com/details-about-the-fatal-tesla-autopilot-accident-released-2017-6?IR=T (access: 9.03.2018).

[6] Without comparison PAs are better seen in cities, e.g. in Phoenix or Pittsburgh, where they are already operated in normal traffic and where passengers can already use them.

[7] http://press.ihs.com/press-release/automotive/self-driving-cars-moving-industrys-drivers-seat (access: 9.03.2018).

[8] J.B. Greenblatt, S. Shaheen, *Automated Vehicles, On-Demand Mobility, and Environmental Impacts*, Current Sustainable/Renewable Energy Reports 2015, 2, p. 74–81.

of these vehicles will be shared (car sharing and ridesharing), which will additionally reduce the level of transport congestion by reducing the number of cars in motion[9]. The "parking cruising" phenomenon, which is usually slow moving in search of a free parking space, which significantly increases the level of congestion, will also decrease. This will happen because the AV can be left anywhere in the immediate vicinity of the destination, and the vehicle will park or go for more travelers.

However, if the use of them will be so easy (according to VW, one tiny device and one click is enough) and pleasant, and in addition cheap[10] will certainly have a "rebound effect" and will stimulate new demand for travel, as well as attract some passengers from public transport. Thus, the combined demand will increase significantly and the level of congestion may increase even more, covering a significant part of the day, and not just periods of communication peaks, especially if the AVs become avaible enough to most users as private cars. Therefore, the replacement of modern cars with autonomous vehicles will have to be subject to precise regulations and will require the creation of new, much more extensive and flexible payment systems taking into account numerous parameters in order to prevent the occurrence of excessive congestion.

The mutual relations between public transport and autonomous vehicles remain unknown. Studies carried out so far show that the high availability of services provided by Uber, Lyft and similar operators who invest heavily in the autonomy (the so-called robo taxi) caused the outflow of some public transport passengers[11]. In the light of these observations, it is reasonable for operators or managers of municipal public transport systems to start offering services of flexible and autonomous public transport carried out by autonomous vehicles. So as not to lead to devastating competition, but enrich and complement the current offer. Small AVs could successfully serve residents of suburbs, delivering them to stops and stations of much more efficient and fast traditional means of transport – railways, subways, trams etc. As well as between the suburbs and wherever due to tight development or other restrictions of entry typical public transport vehicles is currently ineffective or even impossible.

The influence of AV on spatial planning is also a mystery. A typical private passenger car is used on average for only 5% of the time and the remaining nearly 23 hours is parked. This forces the need to create a significant number of parking spaces. Research carried out in American cities indicates that every registered car has an average of 6 times more parking space than it occupies (in Europe from 4 to 5), which means that in developed countries with a high level of motorization public car parks occupy an average of 15% of the surface cities and in their centers about 1/3[12]. The dissemination of AV, especially if they are shared, will make that their usage level will be many times higher than currently owned cars and thanks to this

[9] D. Shoup, *Cruising for Parking*, Access 2007, 30, p. 16–22.

[10] The use of shared autonomous vehicles will certainly be significantly cheaper than with modern taxis, because 40% of the total travel costs are drivers' costs. That is why companies such as Uber invest so intensively in the development of autonomy.

[11] R.R. Clewlow, G.S. Mishra, *Disruptive Transportation: The Adoption, Utilization and Impacts of Ride-Hailing in the United States*, Institute of Transportation Studies, University of California, Davis 2017, p. 24–26.

[12] E. Ben-Joseph, *ReThinking a Lot. The Design and Culture of Parking*, The MIT Press, Cambridge 2012, p. 7.

will allow to recover a significant part of the parking space. It can be used for e.g. housing, trade or services, but also to create parks and places for recreation and rest, which is likely to attract residents closer to the center. In addition, cities will save gigantic financial resources, because the construction of further parking spaces in the centers will cease to be necessary, especially the most expensive ones within multi-level car parks[13]. New parking lots for AV will be fully automatic without access for people, ramps, staircases, lifts etc., which will take up much less space and will be cheaper.

On the other hand, there is a danger that if the time spent in an autonomous car will never be lost again (you will be able to read, sleep, play, watch movies etc.), it will not be as strong as today's motivation to live closer to the center and limit distance traveled every day. As a result, the city will spread even more and an extremely large hybrid urban-rural settlement structure will be created. Such a scenario will lead to the appropriation of huge tracts of agricultural and green areas by housing and road infrastructure, which will entail enormous expenses for the construction and maintenance of this infrastructure and will also increase energy consumption – longer and more frequent trips. Therefore, again a lot depends on proper spatial planning and quality of buildings and services offered, as well as travel costs for autonomous vehicles.

Autonomous vehicles, regardless of the drive, give the possibility of a significant, at least a few dozen percent, reduction in energy consumption and thus the emission of greenhouse gases and other pollutants emitted by cars. This may be due to their ability to travel in convoys and thus significantly reduce aerodynamic drag. In addition, the need to develop high maximum speeds, high power and fast acceleration will disappear, because AV will not break any regulations (especially speed limits) and because especially shared AV will be stripped of the entire social and psychological context of current cars. This will reduce their mass (small, light engines, possibly smaller batteries) and thus the energy needs for their acceleration and maintaining speed[14]. The aforementioned reduction of the congestion level will also have a very positive effect on the reduction of energy consumption. According to the author's research, fuel consumption is in Poznan in the morning rush hours by as much as 50% higher than in optimal conditions[15]. Also on the out-of-town routes, a 25% reduction in energy consumption can be expected, as long as the level of autonomous vehicles in traffic reaches 90%[16]. As a result, the reduction of pollutant emissions will improve the condition of the natural environment and human health and the attractiveness of life in the city will increase, and at the same time it will be possible to reduce expenditure on healthcare in this area. A decrease in greenhouse gas emissions will reduce the risk of catastrophic climate change,

[13] It turns out that in Poznań even a single-level P&R car park can be extremely expensive. A newly built car park on the estate Sobieski cost about PLN 38.000 for a parking place.

[14] H. Igliński, M. Babiak, *Analysis of the Potential of Autonomous Vehicles in Reducing the Emissions of Greenhouse Gases in Road Transport*, Procedia Engineering 2017, 192, p. 353–358.

[15] H. Igliński, *Kongestia transportowa w Poznaniu i wybrane sposoby jej ograniczenia*, Transport Miejski i Regionalny 2009, 3, p. 1–8.

[16] *Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations*, ENO Center for Transportation, 2013, p. 8–10.

unless of course the rebound effect (Jevons paradox) does not occur as a result of the drop in travel costs, and people will not start riding more.

Annually, around 1.25 million people die in road accidents in the world and up to 50 million are injured[17]. Most of them suffer from accidents in developing countries, and the proliferation of AV in these countries will have to wait a long time. However, this does not change the fact that autonomous vehicles are nowadays much safer. Unlike modern human drivers, AV will never break the rules, especially speeding, overtaking on turnings and hills, or enforcing priority, they will not be drunk with alcohol or drugged, they will not be tired or sleepy and will not get aggressive.

As a consequence of a significant drop in car accidents and collisions, the demand for tinsmith and paint services will fall dramatically. Most of the workshops will not be needed anymore. The proceeds from insurance premiums will also be significantly lower and thus the profits generated in this area by insurance companies. The influence of lawyers dealing with cases will also fall, although in Poland in contrast, especially to the USA, this segment of legal services is not well developed. The demand for medical and rehabilitation services for people injured in road accidents will also drop significantly, although in this case it will be a huge benefit for the whole society due to reduced pain and suffering and of course budgetary expenses (medical, emergency and police services). Doctors themselves, the remaining medical staff are so overloaded with work that the fall in the number of patients after accidents should be welcomed with relief, because thanks to that they will be able to better deal with other patients and their illnesses.

The demand for maintenance services provided by dealers will probably also decrease, because these cars will be operated in an optimal way, so their consumption will be lower and instead of repairs, they will be limited only to service inspections resulting from the mileage. It is also assumed that cars will be electric in the future, which means that the number of components and engine components and the transmission that can fail will drop significantly compared to cars with internal combustion engines, as well as the exhaust system which they simply do not have.

A revolutionary change will reach professional truck drivers, city buses and taxis, couriers etc. As the AV becomes popular, the demand for their services will decrease. There will be new jobs related to AV service and their control and coordination, there will also be new opportunities for programmers and IT specialists or accident investigation experts with the participation of AV. However, it should be remembered that the newcomers will be much less than those who will lose their jobs as drivers, which will certainly cause considerable social costs.

A huge question mark is the size of cars produced in the future. According to the author, the volume of production in the future will not change too much. The high level of use of autonomous cars, significantly exceeding the current 5% in the case of private passenger cars and high mileage will make these vehicles will have a much shorter life cycle and will significantly increase the frequency

[17] *Global status report on road safety 2015*, World Health Organization, Geneva 2015.

of their replacement. It will be beneficial that we will eliminate outdated, dangerous and high-emission vehicles from traffic.

In autonomous vehicles, solutions in the field of information technology become extremely important, so it is possible to decrease the importance of typical car manufacturers. The symptom of these changes is the fact that Google, Uber and Tesla have become pioneers of autonomy, of which only Tesla manufactures cars, and so it belongs to companies with very little potential, especially considering the production capacity. It may soon turn out that those car makers who do not make appropriate alliances and acquisitions or do not develop sufficient autonomy competences themselves will be marginalized.

Conclusions

The fact that autonomous vehicles will appear in the future on roads is basically a foregone conclusion. However, the direction in which their development will take place and whether they will free us from the deficiencies of today's transport systems without causing new problems is a matter entirely open and dependent mainly on experts, but first of all on politicians. Politicians must determine the appropriate regulations and, above all, determine the role and place of autonomous vehicles in transport systems and create such payment systems for their use and the services they offer which will shape this role and place properly. Finally, users should be assured that AVs are indeed much more secure than current cars, and that their privacy will not be compromised and that using AV will not end in permanent surveillance and professional drivers will find another job. The potential of autonomous vehicles is huge (first of all, reduction of energy consumption and emissions as well as labor costs, reduction of congestion and infrastructure space demand, as well as increased traffic safety), it should only be properly used and this seems to be the biggest challenge.

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SELECTED TASKS OF CUSTOMER SERVICE MANAGEMENT IN THE LOGISTICS OF TRANSPORT COMPANIES

Abstract

The article presents research results of selected tasks of management of logistic customer service in enterprises of commercial cargo motor transport enterprises, with particular emphasis on the number of logistic customer service standards and customer expectations regarding the level of this service. The survey was conducted among 147 enterprises of commercial cargo motor transport operating in the Silesian Voivodeship. Afterwards, taking into account the entirety of the conducted research procedure, based on the collected primary data, an attempt was made to examine the dependence of selected areas of logistic customer service, occurring in the surveyed cargo transport companies in the Silesian Voivodeship, on the size of these entities.

Keywords: management, logistic customer service, transport company

Introduction

In the dynamically changing economic environment, many of the previous determinants of business success have diminished, and current development trends of many business entities are focused on the management of buyers in logistics. In the area of customer service management in enterprise logistics, a complex model should be adopted, including appropriate service standards and procedures ensuring correct and systematic measurement of this service level taking into account customer expectations.

The aim of this article is to present the results of research on selected tasks of logistic management of customer service in enterprises of commercial cargo motor transport, with particular emphasis on the number of logistic customer service standards and customer expectations regarding the level of this service.

1. Challenges of customer service management in logistics

Currently observed in enterprises, shifting interest in raising product quality, lowering prices or territorial availability of products in the direction of precise defining factors determining professional logistic service, are discussed by R.H. Ballou[1], D.J. Bowersox, D. J. Closs and M.B. Cooper[2], M. Christopher[3], D. Kempny[4], D. Kisperska-Moroń[5] or M. Kramarz[6].

M. Chaberek[7], S. Chopra and P. Meindl[8], S. Cook[9] associate the service of buyers in logistics with logistic support, which is the culmination of the basic process related to the production and delivery of goods or services. In this sense, logistic service which ensures that the specified good, in a specified quantity, at a certain time, of a certain quality, while maintaining the costs accepted by the consumer, will be at the recipient's, providing a customer service that determines the output of the logistic system process of satisfying basic needs. Therefore, the authors do not indicate spontaneous logistic customer service, but always connected with the basic process of producing goods and services aimed at satisfying specific needs.

As part of customer service management[10], key logistics activity synchronizes all company activities towards the implementation of tasks such as[11]:

– defining the wishes and needs of the consumer in the light of the experience of services;
– defining the service as a response to the customer's request;
– supply of the desired level of services.

With regard to all business entities, the postulate of service in logistics is similar: the use of methods and tools to gain market, satisfactory to the customer, profitable and the appropriate quality of services provided. Therefore, the logistic service mechanism focuses the useful and necessary attributes of economic life in the competitive economy, in particular by stating the optimal level of service and its quality as well as the effectiveness of the activities carried out. For enterprises, the basic task is to establish proper customer service standards based on measurement of relationships between alternative customer service levels and the costs of their

[1] R.H. Ballou, *Business Logistics: Supply Chain Management*, Prentice Hall, United Kingdom 2003.
[2] D.J. Bowersox, D.J. Closs, M.B. Cooper, *Supply Chain Logistics Management*, McGraw Hill, United Kingdom 2009.
[3] M. Christopher, *Logistics & Supply Chain Management*, Financial Times Prentice Hall, Harlow 2011.
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[9] S. Cook, *Customer Care Excellence. How to Create an Effective Customer Focus*, Kogan Page Ltd., London 2002.
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development and maintenance, to ultimately adopt a rational policy for various market segments.

In the light of the previous considerations referring both to the issues of the logistic level of customer service defined within the company and the analysis of elements implicating the formation of services from the point of view of the clients themselves, it is possible to indicate fundamental guidelines in the field of management of this area in business entities[12]. The process of proper management of the logistic customer service is analyzed by M. Christopher[13], P.M. Price and N.J. Harrison[14], A. Rushton, P. Croucher and P. Baker[15], and they formulate the following criteria:

– identification of real market segments;
– identification of customer needs or identified demand within individual market segments;
– specification of measurable customer service standards;
– trade-off[16] between different levels of customer service and their costs;
– measuring the services provided;
– contact with clients in order to indicate the evaluation of the performed services.

The article further discusses the results of research on selected tasks of logistic management of customer service among the aforementioned, i.e. determination of clearly formulated, measurable customer service standards and communication with customers regarding their expectations for the level of services provided.

2. Research methodology

In order to identify selected tasks of logistic management of customer service in the operation of commercial cargo motor transport enterprises[17] in the Silesian Voivodeship, primary research was carried out by the author. The cognitive method used was the survey method, in which the categorized technique of obtaining primary information was used – a questionnaire.

The survey was conducted among 147 enterprises of commercial cargo motor transport operating in the Silesian Voivodeship. As a result of obtaining, processing and analysis of the empirical material obtained in the survey using the questionnaire, the determinants of the scope of logistic customer service in the surveyed enterprises of commercial truck transport were presented.

Afterwards, taking into account the entirety of the conducted research procedure, based on the collected primary data, an attempt was made to examine the dependence of selected areas of logistic customer service, occurring in the surveyed enterprises of commercial cargo motor transport in the Silesian Voivodeship, on the size of these entities. For this purpose, for the analysis of primary

[12] M. Romanowska, *Podstawy organizacji i zarządzania*, Difin Publisher, Warsaw 2001.
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[16] Cf. D. Kempny, *Logistyczna obsługa klienta…*
[17] K. Wojewódzka-Król, E. Załoga, *Transport. Nowe wyzwania*, PWN, Warsaw 2016.

data in the aspect of selected problems in the conducted statistical analysis, one of the most commonly used measures was the Pearson linear correlation coefficient, determined for correlation tables. This coefficient is defined by the formula[18]:

$$r_{xy} = \frac{\sum_{i=1}^{k}\sum_{j=1}^{l} n_{ij} \cdot (\dot{x}_i - \bar{x}) \cdot (\dot{y}_j - \bar{y})}{\sqrt{\sum_{i=1}^{l} n_i (\dot{x}_i - \bar{x})^2 \sum_{j=1}^{k} n_j (\dot{y}_j - \bar{y})^2}},$$

where:
– the x and y features are presented on an ordinal scale,
– n_{ij} means the number of cells corresponding to individual sets $x_i\, y_j$.

The use of an ordinal scale in the case of information available is possible in only a few cases, however the usefulness of this coefficient is also based on the lack of requirements for filling all cells of the correlation table. It is also postulated that due to the difficulty in assessing the severity of the assessment of the correlation coefficient, its statistical significance should be tested. For this purpose, the significance test of the correlation coefficient is used. In the case of these studies, the following hypotheses were always assumed[19]:

$$H_0: p = 0,\ H_1: p \neq 0,$$

whose test is the statistic:

$$z = \frac{r_{xy}}{\sqrt{1 - r_{xy}^2}} \cdot \sqrt{n},$$

for n ≥ 122, which assuming equity H_0, has a normal distribution → N (0, 1) and:

$$t = \frac{r_{xy}}{\sqrt{1 - r_{xy}^2}} \cdot \sqrt{n-2},$$

which assuming equity H_0 has Student's t-distribution with n-1 degrees of freedom.

3. Establishing logistic standards of customer service in the surveyed enterprises

According to the analysis of the answers to the first two questions contained in the questionnaire form, micro entities dominated among 147 surveyed enterprises, which constituted 76% of the research population (112 enterprises). The share of small entities, constituting 16.5% of the total number of respondents (24 enterprises) was also significant. At the same time, medium-sized and large enterprises recorded a small share in the study, together constituting 7.5% of the research sample (11 enterprises).

[18] S. Ostasiewicz, Z. Rusnak, U. Siedlecka, *Statystyka – elementy teorii i zadania*, Wroclaw University of Economics Publisher, Wroclaw 2011.
[19] M. Sobczyk, *Statystyka*, PWN, Warsaw 2017.

Determination of clearly defined and measurable standards of logistic customer service in the surveyed business entities was an important issue of the research tool addressed to all (N = 147) respondents. Respondents asked to indicate whether the elements of their logistic service were subject to standardization and if so, how many standards were established in the surveyed entities, most of them were granted by the lack of them – this was the answer of 51 entrepreneurs (34.7%). The remaining 96 companies confirmed having established logistic service standards for their buyers, of which 33 entities (22.4%) recorded one stated logistic service standard, 21 entities (14.3%) recorded two standards and 36 entities (24.5%) three standards. The number of entrepreneurs who established a greater number of standards of their logistic customer service was negligible: 3 companies (2%) had from four to five standards, six to ten standards – 2 economic units (1.4%) and only one entity (0.7%) declared above ten standards. Figure 1 presents the distribution of responses to the question about having established logistic customer service standards in the surveyed enterprises.

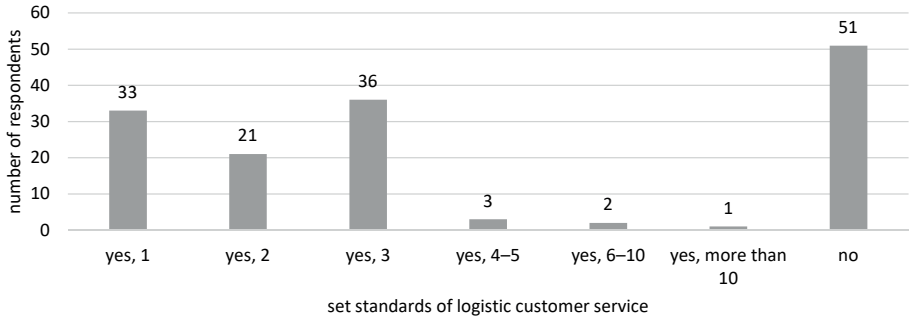

Figure 1. Having set standards of logistic customer service by the surveyed enterprises
Source: own elaboration

The next question in the questionnaire was addressed to 96 respondents who, in response to the previous issue, confirmed having established logistic service standards for their buyers. Therefore, the size of the shares was determined in relation to the number of responses received, limited to 96. Among entrepreneurs who declared having precise logistic customer service standards, as much as 75% (72 entities) indicated full consideration of the expectations of their clients in determining the standardization of elements of this service. Up to 50% of buyers 'expectations in relation to the level of logistic service offered were taken into account only by 6 entities (6.2%), and over 50% of buyers' expectations – by 16 entities (16.7%). Two companies (2.1%) admitted that their customers' expectations were not taken into account in relation to the level of logistics service offered. The distribution of responses received from the surveyed entrepreneurs to the question of taking into account the expectations of customers in relation to the level of logistic service offered in enterprises confirming the possession of established standards of this service, is presented in Figure 2.

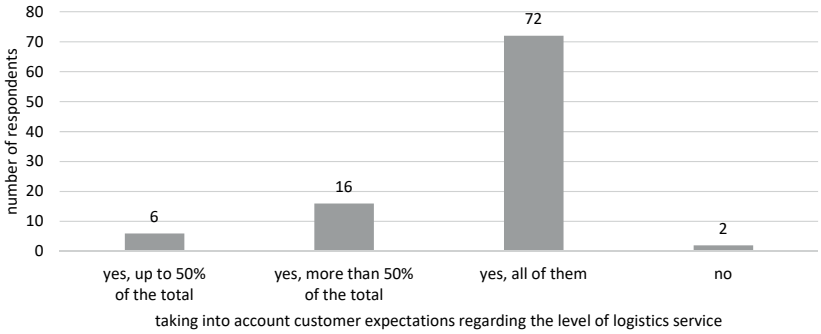

Figure 2. Taking into account customer expectations regarding the level of logistics services in enterprises confirming the possession of established standards of this service
Source: own elaboration

4. Standards of logistic customer service and the size of the surveyed enterprises

The distribution of the number of logistic customer service standards in the surveyed enterprises depending on the size of enterprises is presented in Table 1. High level of correlation: 0.688, indicates a greater tendency to determine a sufficiently high number of standards by large and medium enterprises in comparison with smaller units. The largest group of micro transport enterprises, 44.6%, admitted the complete lack of established standards. Almost half of these enterprises – and in relation to the whole sample over 1/3 – are entities that recorded only one established standard of logistic service. This result confirms poorly demonstrated understanding for the needs related to the level of logistics service desired by customers and their viewpoint.

Table 1. Distribution of the number of logistic customer service standards in the surveyed enterprises depending on the size of enterprises

Number of logistic customer service standards	Type of enterprise			
	micro	small	medium	large
no	50	1	0	0
yes, 1	31	2	0	0
yes, 2	18	2	1	0
yes, 3	13	19	4	0
yes, 4–5	0	0	3	0
yes, 6–10	0	0	0	2
yes, more than 10	0	0	0	1

Source: own elaboration

Table 2 presents the distribution of respondents' responses to include the expectations of customers in relation to the level of logistic service in enterprises

confirming the possession of established standards of this service, depending on the size of enterprises. Between consideration of defined standards and the size of the surveyed enterprises, there is a clear correlation at the level of 0.306, which proves that the bigger the enterprise, the wider the opening to the expectations and proposals from the customers. Large enterprises, for example due to financial, organizational or HR resources, are able to realize more potential orders of various types. According to the presented research results, almost all companies that take into account the expectations of customers, implement them in most procedures. Only 8.3% of enterprises with established logistic service standards do not take these expectations into consideration or account for less than half of them.

Table 2. Considering customer expectations regarding the level of logistics services in enterprises confirming having established standards of this service depending on the size of enterprises

If the company's logistic customer service standards are set, do they take into account customer expectations regarding the level of service?	Type of enterprise			
	micro	small	medium	large
yes, up to 50% of the total	1	5	0	0
yes, more than 50% of the total	11	3	2	0
yes, all of them	47	16	6	3
no	2	0	0	0

Source: own elaboration

Conclusions

A full understanding of the needs associated with having a wide range of logistic service standards, i.e. more than three basic standards, was shown by the least entrepreneurs – about 4%. The lack of recognition of the need to recognize the expectations of buyers with regard to the level of individual elements of logistic service is alarming and close to 2% of the surveyed entities. Determination of clearly defined and measurable logistic customer service standards in the surveyed business entities obtained a similar distribution of responses, i.e. nearly 35% of respondents admitted not applying normalization of logistics service elements, but among entrepreneurs who declared having precise logistics service standards, as many as 75% indicated full taking into account the expectations of their clients.

The attempt to investigate the dependence of the scope of logistic customer service, occurring in the surveyed enterprises of commercial cargo motor transport in the Silesian Voivodship, on the size of these entities, brought satisfactory results in the majority of the phenomena considered. The analysis of primary data obtained from the respondents' answers to questions in the questionnaire, in relation to the size of the surveyed enterprises, with the use of selected statistical measures, confirmed statistically significant dependencies. Due to the small values of the obtained statistical measures, the conclusions included in the considerations are rather hypothetical, while the generalizations formulated on the basis of them can be considered as interesting research theses, constituting a contribution to further basic research.

The observed diversification of the advancement of the logistics scope of customer service in the surveyed entities depends on many factors and one of the most important is the size of enterprises of commercial transport of cargoes. The establishment of large, medium, small and micro enterprises from the commercial cargo motor transport sector, their place on the market of transport services and development opportunities are the resultant of many external and internal conditions. The most important external factors are undoubtedly creation of reasonable conditions for the functioning of entities from the state policy, as well as the sphere of competition. Internal factors determining the framework for the activity of transport enterprises are primarily their economic and financial condition, which is expressed both in human resources, material, financial, IT, as well as the ability to manage them. The distribution of responses of respondents depending on the size of enterprises usually confirmed that with the increase in the size of the surveyed enterprises, they showed an increasing tendency to carry out the measurements mentioned above.

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INNOVATIVE SOLUTIONS AS A MODERN DIRECTION OF THE SEA TRANSPORT DEVELOPMENT

Abstract

The aim of the article is to assess the potential of intelligent transport solutions. The article focuses on sea transport. It presents the latest trends in transport and logistics that we can expect in the coming years and describes highly advanced solutions – completed projects, as well as those in the development phase. The solutions concern both projects from the world market and the Polish market. The sources of changes and market needs were also presented and focused on the sources of financing for innovative projects. The research problem presented in the article is: is the constant and successive introduction and implementation of intelligent and innovative solutions in sea transport a contemporary and irreversible trend defining the directions of development of transport systems and their modernization on a global scale?

Keywords: sea transport, innovations, new technologies

Introduction

The transport industry is experiencing a sharp breakthrough and there is no doubt about it. Although it is not entirely clear in which direction the world of widely understood transport will go, one thing is certain – thanks to advanced technologies and concepts of large industrial concerns, we will experience real volatility in the coming years. Contemporary innovations, scientific and technical progress in the field of motorization and transport influence the increase of security of infrastructure and means of transport as well as the expansion of logistic concepts. Innovation implies favourable conditions for the proper functioning of transport. Innovations in the rapidly developing TSL sector are an inseparable element

increasing the level of management and, consequently, promoting economic cohesion by increasing the level of service quality.

1. Trends in transport and logistics

The TSL industry is undoubtedly getting stronger, from year to year introducing new technologies. Among the most important logistics trends lies widely understood automation under which the automation of warehouses and processes is hidden. An equally important and promising trend is autonomous transport and autonomous vehicles turn out to be realistic ways to reduce transport costs and increase safety. The other trends are the development of the internet model of B2B business relations, the management of large amounts of data – Big Data, and the idea of the Internet of Things, where the nodes of the network will be devices that communicate with each other without human participation[1].

2. Sources of changes and market needs

Changes are necessary for companies that want to stay in a rapidly growing market. The dynamics are subject to modification in time and quickly changing trends determine new market needs. Along with changes in technologies and life styles of societies, preferences, expectations and aspirations of transport users evolve. Transport is a process and a human plays an important role in this process, as he satisfies his needs and desires by transporting. When talking about the sources of changes, we also need to mention the transport needs that dictate these changes. The needs stem mainly from the development of the global economy, as well as the integration of the economy and society. Economic growth, growing international trade exchange and high level of foreign investments create excellent prospects for the development of the logistics services market, and thus generate demand for transport services[2]. Transport services, on the other hand, are dictated by a human for whom quality, price and delivery time are what counts today.

3. Innovative solutions in sea transport

In sea transport, interesting and innovative solutions that are the result of technological development not only in the world, but also in Poland appear more and more often. More advanced units produced by the Polish industry create an excellent foundation for cooperation between shipyards, designers, ship owners, manufacturers of navigation systems and sea carriers. Dynamic changes are not only cooperation, but also the pursuit of ecological ships. Modern lubricants guarantee

[1] M. Malinowska, *Big Data w transporcie i logistyce*, Eurologistics 2017, 2, p. 52.
[2] http://www.logforum.net/vol1/issue1/no6/6_1_1_05.html (access: 26.02.2018).

safety, proper engine operation and cost reduction[3]. The key challenge for modern manufacturers are limits on the sulfur content and they are the direction of changes in fuel production. However, the prospect of the use of LNG-powered engines by ship owners brings financial benefits. It is planned that the production of gas in the world by 2030 is expected to double, with the development of transmission infrastructure shipping will gradually shift into ecological navigation. The ecological character of the units will consist of the introduction of partially autonomous ships with a reduced number of crew, which will reduce energy consumption and production, resulting in significant savings in the cost of maintaining the ship. Autonomous ships and solutions in maritime transport are "something" that is already happening, although current regulations need appropriate guidelines and radical changes, because technology undoubtedly overtook the legal sphere.

In cooperation with two specialized companies – TECONJA (German juice manufacturer) and LIQUA (expert in the field of packaging technology), the world's second largest container carrier CMA CGM proposed a solution dedicated to transporting liquids in 40 – foot refrigerated containers. The system called REEFLEX allows for filling with liquids, i.e. fruit juices, milk, syrups, oils and other liquids to the designed bag, filling the container tightly. Thanks to the special properties of the bag, this technology allows filling between 12 000–24 000 liters. Filling the bag with liquid or emptying takes place thanks to the external pumping system and takes about 35 minutes. Installing the bag in the container takes only 3 minutes and does not require that during loading there is someone inside, through which the loading is safe. Each of the bags is disposable and is fully recyclable and is manufactured based on the needs of customers meeting the highest hygiene and safety requirements. The modern solution is an alternative to the current liquid transport in mass transport. Thanks to REEFLEX, from the place of loading to the destination, fruit juices, milk, oil and other liquids are kept at the optimum temperature during transport and delivery. According to CMA, CGM REEFLEX helps to maintain the nutritional and chemical properties of the product thanks to a sterile environment and controlled temperature maintained precisely in the range of –35°C to +20°C[4].

The first P310 ferry built in Poland on 18 May 2017 left the Crist S.A. shipyard in Gdynia. The ship is 96.35 m long and 15 m wide and 5 m high. The unit is designed to transport 90 passenger cars and 372 passengers. The ship was designed and built in accordance with the provisions of the classification society DNV GL for the class notation + 1A1 Car Ferry, B, Battery (Power) E0, Ice 1B, PET, R3; GMNKC.

[3] A. Kulbacka, P. Kołoda, *Innowacje w morskich środkach transportu podnoszące jego ekologiczny charakter*, Scientific Journals 2014, 102, p. 68–73.

[4] https://www.cma-cgm.com/local/mexico/news/103/reeflex-the-new-cma-cgm-flexitank-solution-for-transport-of-liquids-in-40rh (access: 22.02.2018).

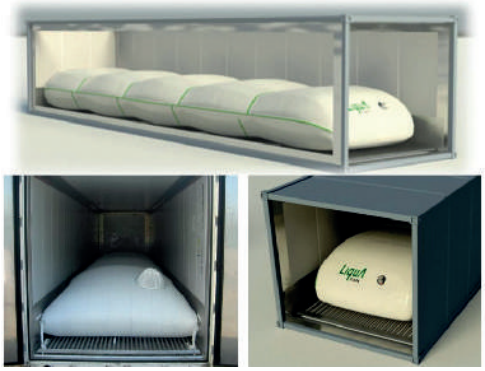

Figure 1. Reeflex technology
Source: https: //www.cma-cgm.com/local/mexico/news/103/reeflex-the-new-cma-cgm-flexitank-solution-for-transport-of-liquids-in-40rh (access: 22.02.2018)

It is a modern diesel-electric hybrid unit, it is equipped with three main diesel engines, two azimuth propulsors and a set of batteries. The azimuthal propulsors supplied by Rolls Royce, 900 kW – each, at 1200 rpm, provide the unit with a speed of 11 knots. Thanks to technologies adapted to unfavorable climatic conditions through the use of a system based on Siemens subassemblies with a lifetime of, among others. For 10 years, it is possible to work during low northern temperatures and in case of heavy snowfall. The ship has a set of batteries that are loaded automatically when loading and unloading the shuttle, which takes about 7 minutes.

Figure 2. Hybrid ferry Elektra
Source: http://www.crist.com.pl/podpisanie-kontrakt-z-finferries,91,pl.html (access: 20.02.2018)

Battery charging is supported by two independent photovoltaic installations with a total capacity of 12 kW and the entire installation is built in the front and rear wall of the superstructure and consists of 86 polycrystalline panels of the company Activesol. A highly automated unit can be operated by only a three-man crew. Support for the crew is the installation of an automatic mooring system at the marinas

in Nagu and Pargas and a battery charging system developed by Cavotec. The ferry is intended for navigation on sheltered waters, on a 1.6 km long route linking the islands of Nagu and Pargas in the Turku Archipelago[5].

The project "Applied research in the area of navigation, control, communication and data exchange between an autonomous floating vessel and the aircraft" by the National Center for Research and Development received co-financing under Measure 4.1 of the Intelligent Development Operational Program 2014–2020 co-financed from the European Regional Development Fund, Sub-measure 4.1.4 "Applied research". The project was given the codename AVAL-Autonomous Vessel with an Air Look. The project implementation period will cover the period from 01/06/2017 to 31/05/2020, while the project budget is PLN 10 341 336.94 and the co-financing awarded is PLN 9 272 030.64[6].

The goal of the AVAL project is the implementation of industrial and development research, the results of which will be implemented in the technology of an autonomous sea ship. The key element of the technology is the system of innovative maritime navigation, which will also use navigation devices installed on the ship, as well as data from visual observation conducted by unmanned aircraft. The effects of the project will be used in a product based on AVAL technology, and its implementation in the maritime transport market is expected in 2021[7].

The assumption of the program is:

– designing the technology of an autonomous sea ship cooperating with an autonomous drone;
– certification of autonomous surface vessels, drones and operators;
– development of procedures and expert opinions;
– increasing the safety of environmental users;
– risk assessment for the use of drones in the marine and offshore environment;
– transfer of knowledge and implementation of technological innovations.

Figure 3. Prototypes of AVAL technology tested on ships in 1:25 scale
Source: http://www.aval-project.pl/ (access: 18.02.2018)

[5] http://www.crist.com.pl/podpisanie-kontraktu-z-finferries,91,pl.html; http://www.portalmorski.pl/stocznie-statki/35762-oficjalny-chrzest-promu-elektra-ze-stoczni-crist-video (access: 20.02.2018).
[6] http://pb.edu.pl/archiwa/25634 (access: 15.02.2018).
[7] http://www.aval-project.pl/ (access: 18.02.2018).

4. Financing transport innovations

Demanding transport sector requires financing on many levels, and the main sources of transport strategies implementation are: European funds, state budget, local governments budget, private investors' funds, loans and credits, National Road Fund, National Fund for Environmental Protection and Water Management.

The potential of autonomous solutions was noticed not only by the largest producers and entrepreneurs such as Volvo, Tesla, Google, Rolls-Royce, Elon Musk, but also the European Union, through its EU programs, supports research and development in the field of intelligent transport[8]. The National Research and Development Centers, competitions and start-ups as well as university researchers come with help. The driving force leading industries to multi-million investment in the field of autonomous vehicles is not only technological development, but what's more – customer needs. Although, for now, innovations are largely focused on support, only industry 'giants' are testing full automation.

Conclusions

The concept of introducing intelligent transport vehicles has enormous potential. Innovative solutions require further development of details, ranging from the lack of conditions and legal regulations to deficiencies in the appropriate infrastructure. The breakthrough can only take place due to particular and determined actions, with the simultaneous cooperation of states and entrepreneurs. The analysis clearly shows that the revolution in intelligent and innovative solutions in transport has a global dimension and we are unable to stop it. Successive implementation and implementation of advanced solutions in road, rail and sea transport is one of many irreversible trends in logistics. The prospects are promising, but only decisive steps will help consolidate this future concept.

Despite challenges such as:

- technological capacity;
- security;
- responsibility;
- legal policy and regulations;
- high financial expenses;
- automated or fully autonomous vehicles in transport will significantly affect the future of transport and logistics.

The closest to the introduction of fully autonomous vehicles is road transport, which is also the most developing branch, making it the largest potentate for

[8] Official Journal of the European Union L 347 Volume 56 Legislation 20/12/2013 Polish edition Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11.12.2013 laying down rules for the participation and dissemination of Horizon 2020 – the Framework Program for Research and Innovation (2014–2020) and repealing Regulation (EC) No 1906/2006 Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11.12.2013 establishing "Horizon 2020" – the framework program for research and innovation (2014–2020) and repealing Decision No. 1982/2006/EC.

the introduction of intelligent solutions. The most popular market players such as Google Car set the direction of following intelligent solutions. Competitive advantages are exerted by pressure on automotive giants who are outdoing themselves in their innovative concepts. However, before the automotive industry there is an equally important exam which is building trust among people, because evolving technical progress and legal regulations without people's trust do not matter.

Intelligent solutions also do not omit sea transport. According to marine reports, ship-related accidents happen less frequently, thanks to the systems that modern units are equipped with. Autopilots and anti-collision systems are just a prelude to the future autonomy of ships, which has its origin. Switching sea transport to the innovative development course requires involvement of several entities, i.e. public authorities, entrepreneurs, industry, research and development communities as well as transport users. Only and exclusively the creation of a new generation of infrastructure, means and transport systems will allow for the innovativeness of maritime transport branches.

The goal which is guided by innovative and intelligent transport vehicles is above all safety. The unproductive human factor will be eliminated or reduced to a minimum and the forecasts indicate that the number of accidents will fall sharply. As it is known, a computer versus a human is always a 1:0 result. The second equally important factor that appears in many debates about autonomous vehicles is the reduction of CO_2 emissions and the reduction of fuel consumption. For many years, the European Commission was looking for optimal ways to make the economy more environmentally friendly and at the same time economical. The European Union plan assumes that by 2050 the European Union should reduce greenhouse gas emissions by 80%. compared to the 1990 level, and all sectors must be involved, including the transport sector. The reduction of CO_2 emissions will be achieved thanks to network-powered hybrid and electric vehicles as well as increasingly popular biofuels.

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CHARACTERISTICS OF POLISH INTERNATIONAL FREIGHT TRANSPORT

Abstract

The aim of the article was to present data on the condition of the Polish sector of international freight transport, including transport potential, transport performance according to types of transport and its share in the European market, as well as the results of ITS cost studies. The results of the average cost of 1 vehicle kilometers traveled of milage and unitary costs in the years 2009–2016 were analyzed in the surveyed companies performing transport mainly on the EU market.

Keywords: transport heavy goods vehicles, costs

Introduction

The freight transport market in Poland is a market with great development opportunities and at the same time functioning in conditions of increasingly more intense domestic and international competition. In the case of international transport, the fact that the governments of various EU countries take attempts to protect them against their own carriers is additionally worrying. Also, the EC's plans (mobility package) aimed at unifying the economic and social conditions of transport companies on the EU market will increase the cost of the activities of Polish enterprises of international freight transport, and thus the possible loss of advantage in the competitive transport market.

It is important for authorities responsible for the Polish transport policy to have up-to-date data on the situation on the transport market and change trends. The task of advisory entities for the Ministry of Transport, such as the Motor Transport Institute is among others monitoring of selected areas of the car transport market, including the international transport market. One of the elements

is the examination of the formation of average unit costs in international freight transport companies registered in Poland, including those operating on the EU market. Costs are a synthetic measure in which both external factors and internal factors affecting enterprises are reflected.

1. Development of the potential and work of international freight transport

Road transport in Poland in recent years and especially from the year of Poland's accession to the EU, thanks to the skills of its staff and its efforts and also due to lower costs of running business (including lower costs of employing drivers) in comparison with transport companies of the so-called "old" EU, strengthened its position as the leader of the EU transport market in international transport.

The main factors contributing to the dynamic development of international road transport companies in Poland in recent years were[1]:

– liberal rules of access to the profession of a carrier and the transport market;
– the abolition of customs barriers within the EU;
– market globalization;
– an improving economic situation in Europe;
– geographical location of Poland;
– easy access to means of transport;
– lower costs of Polish carriers in comparison with the costs of Western carriers;
– the ability of the Polish carriers to acquire the market.

According to the International Transport Office of the General Inspectorate of Road Transport, international transport (as at the end of 2016) was performed approximately by 32 100 companies registered in Poland[2] (with valid licenses), which is less than three times as compared to the situation in December 2004[3] (Figure 1).

The number of licenses issued by companies performing international transports as at the end of 2016 amounted to approximately 205 400 and increased less than three and a half times compared to the corresponding number at the end of 2004 (Figure 2).

[1] J. Waśkiewicz, Z. Kordel, I. Balke, P. Pawlak, *Badania średnich jednostkowych kosztów w przedsiębiorstwach transportu ciężarowego za okres II półrocza 2003 r. i I półrocza 2014 r.*, ITS Papers No. 6403/ZBE, Warsaw, 30.04.2015.

[2] By convention, in a simplified form, the further part of the article is also used to describe the term "Polish truck transport" referring to enterprises registered in Poland.

[3] Drawing based on: K. Bentkowska-Senator, Z. Kordel, J. Waśkiewicz, *Transport samochodowy ładunków*, ITS Publisher, Warsaw 2009, p. 47; Report – Documents issued by GITD – valid in legal transactions, as at December 31, 2015, www.gitd.gov.pl (access: 22.02.2018).

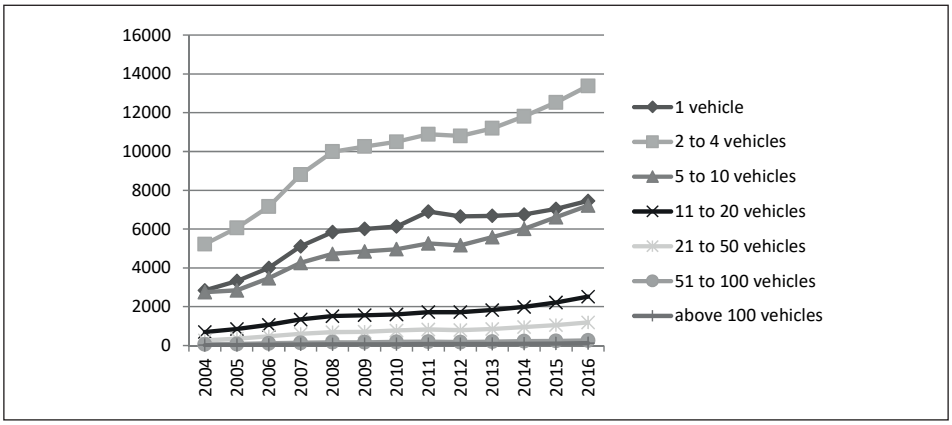

Figure 1. The number of international freight transport companies in Poland in the years 2004–2016 according to their size groups measured by the number of trucks [enterprises]
Source: own elaboration based on: GITD data

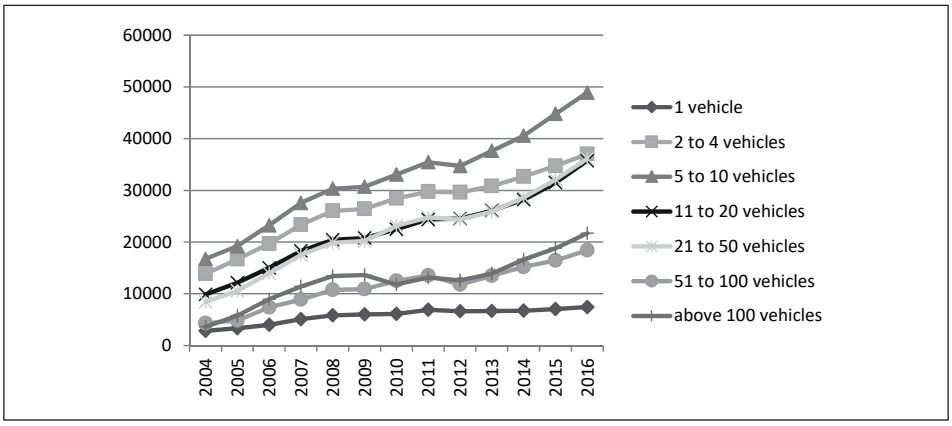

Figure 2. The number of trucks in international freight transport companies in Poland in the years 2004–2016 according to their size groups measured by the number of vehicles [vehicles]
Source: own elaboration based on: GITD data

In the years 2004–2016, the average number of trucks in the statistical enterprise of international transport of loads increased from 5 vehicles to 6.4.

The total transport carried out by Polish freight transport with maximum permissible weight (Dmc) exceeding 3.5 Mg[4] in 2016 amounted to 1331.7 million tons, and transport work was 290.7 billion FTKs (an increase less than twice, and almost three times higher than in 2004). International transport amounted to 242.9 million tons in 2016, and transport work to 184.1 billion FTKs[5] (an increase of nearly six times and more than four times higher than in 2004) (Figure 3).

[4] Central Statistical Office – "Transport – results of operations" in 2014, Methodical notes, p. 25.
[5] Central Statistical Office – "Transport – results of operations" in 2016, p. 169.

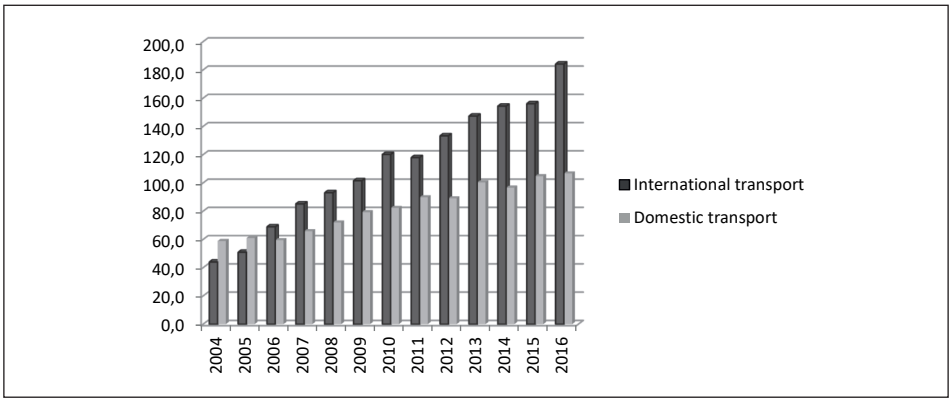

Figure 3. Transport performance of Polish freight transport made with vehicles over 3.5 Mg dmc in the years 2005–2016 [billion FTKs]
Source: own elaboration based on: CSO data – "Transport – results of operations" for the years 2005–2016

Generally, in Polish freight transport, an increase in the average transport distance of 1 ton of cargo was observed, from around 140 km/t to around 220 km/t. This statistically documented phenomenon was the result of a dynamic increase in the share of transport work in international freight transport in total from 42.3% in 2004 to 63.3% in 2016. The average distance of 1 ton of cargo in international transport in 2004 was about 1030 km/t, and in 2016 about 760 km/t, which, with the high growth rate of international transport performed by lorry transport, indicates that Polish carriers will take over shorter distances in the discussed years.

In addition, in the analyzed period, an increase in the average annual transport performance of a statistical truck operated in international transport was noticeable. In 2005, the average efficiency of transport performance amounted to around 701.000 FTKs/vehicle, and in 2016 about 896 thousand FTKs/vehicle (Figure 4).

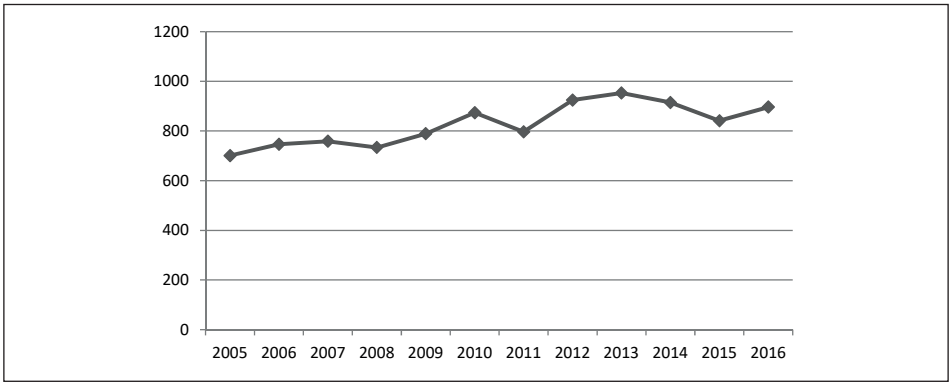

Figure 4. Average efficiency of transport performance of a statistical vehicle in Polish international transport in the years 2005–2016 [FTKs/vehicle]
Source: own elaboration based on: the data from the Central Statistical Office "Transport – results of operations" in the years 2005–2016

Initially, the increase was mainly due to the dynamic development of demand for transport due to the development of international exchange of goods and the growing competitiveness of Polish carriers on the international transport market (cabotage transport and transport between third countries). Some decrease in the average annual transport performance of a statistical truck in the years 2013–2015 was influenced by the growing competition on the international road transport market caused by the strong expansion of carriers of countries such as Lithuania, Estonia and Slovakia. The competitiveness of road transport from these countries was influenced by on the decline in rates for transport services on the European market observed in recent years, including the reduction of Polish carriers' freight rates, resulting in a decrease in their profitability.

In the structure of types of cargo transport by international road transport from 2005 to 2016, the export and import of cargo mass to Poland increased over three times. In addition, transports carried out by Polish companies between foreign countries increased significantly (over seven times according to transported tons and five times in transport performance) and cabotage transport (less than 16 times in the mass of transported loads and 20 times in transport work) (Table 1).

Table 1. Transport and transport work of Polish international freight transport in 2005 and in 2016 by type of transport

	2005		2016		Dynamics (2005 = 100%)	
	(t)	(mln t)	(t)	(mln t)	transport	transport work
Total international transport including	52 551	50 886	242 858	184 115	462.1	361.8
export	21 286	20 570	72 980	62 206	342.9	302.4
import	1 953	19 018	63 573	55 901	325.5	293.9
Transports between foreign countries	9 314	10 645	68 261	53 037	732.9	498.2
transit through Poland	–	–	3 709	5 831	–	–
cabotage	2420	653	38 044	12 971	1572.1	1986.4

Source: own elaboration based on: CSO data – "Transport – results of operations" for the years 2005–2016, p. 169

2. Quality of the fleet in terms of emissions standards for exhaust gases

The high competitiveness of Polish international carriers resulted not only from price competitiveness, but also from quality, which was exemplified by the development of a modern (according to the pollutant emission standards) park in the structure of used vehicles.

Vehicles complying with the Euro 5 and Euro 6 emission standards for exhaust gas pollution in 2016 accounted for 69.1% (in 2015 60.8%) of the total park in these enterprises (Figure 5).

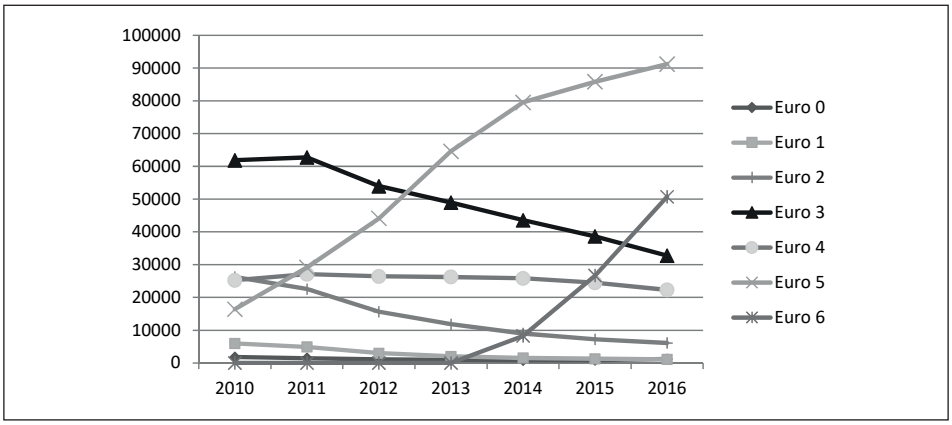

Figure 5. The number of heavy vehicles in international transport companies according to emission standards for exhaust gases in 2010–2016 in Poland [pcs]
Source: own elaboration based on GITD data: Report – Documents issued by GITD – valid in legal transactions, as at December 31, 2015, www.gitd.gov.pl (access: 22.02.2018)

It should be emphasized that among the registered in Poland companies of international freight transport, the share of trucks complying with the Euro 2 and earlier standards declined significantly.

3. Transport of Polish international freight transport against the background of EU transport

Polish international carriers definitely dominate in the transport work of the EU, international truck transport[6] (Figure 6). In 2005–2015, this share increased from 8.2% to 25.1%.

For example, in 2015 the share of German carriers in transport performance on the EU market amounted to 7.3% and French carriers accounted for around 2%. This fact is the result of high competitiveness of Polish road carriers on the international market.

The development perspectives of tasks facing Polish freight transport are also positive. According to expert forecasts, a relatively significant increase in the transport performance of this transport is expected by 2030 compared to the transport work in 2016.

[6] Central Statistical Office – "Transport – results of operations" in 2015, p. 284.

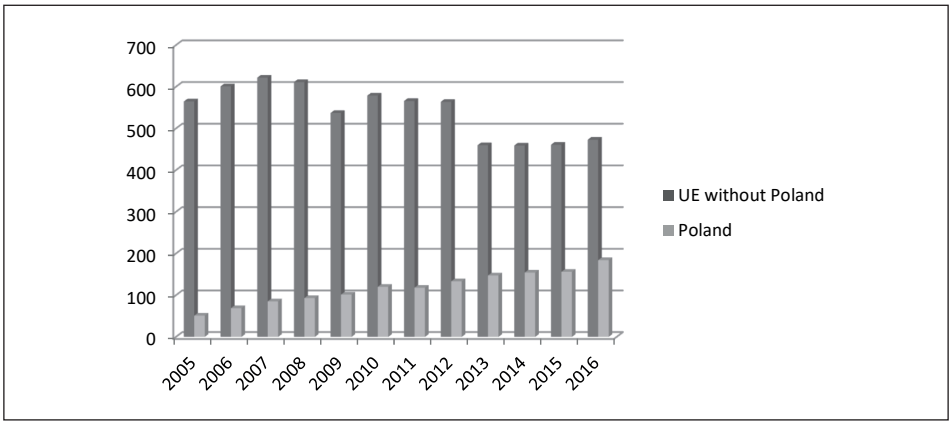

Figure 6. Transport work performed by Polish international freight transport against the background of international freight transport work in other EU countries in 2005–2015 [billion FTKs]
Source: own elaboration based on: CSO data – "Transport – results of operations" for the years 2005–2016[7]

4. Costs tests in international transport

The competitive costs (compared to other carriers) of unit costs were determined by the market success of Polish international road carriers. Examined by ITS in cooperation with the ZMPD, the average cost of 1 mileage in the surveyed group of Polish enterprises with a dominant share of transport in relations with markets in other EU countries, universal rolling stock over 12.0 Mg dmc, in 2016 amounted to PLN 3.85/vehicle kilometers traveled[8] (Figure 7).

The dynamics of changes in average costs of 1 vehicle kilometers traveled of mileage in the field in question in 2009–2016 amounted to around 129%. The increase in average costs and mileage in the analyzed period was mainly due to the increasing costs of fuels, an increase in driver salaries and an increase in the cost of using roads. Fuel costs increased by about 33% during this period, road toll costs increased by over 120%, and driver costs, drivers' delegations and employer's social insurance costs increased by 66% (Table 2).

[7] J. Waśkiewicz, Z. Kordel, S. Dorosiewicz et al., *Projekcja rozwoju rynku międzynarodowego transportu ciężarowego w Polsce do 2030 r. Uwarunkowania, scenariusze i efekty*, ITS Papers No. 06/17/ZBE/002 (in progress).

[8] J. Waśkiewicz, Z. Kordel, E. Kamińska, P. Pawlak, *Badanie stanu i kierunków zmian na rynku transportu samochodowego w Polsce*, part 2, *Badanie kosztów i stawek przewozowych w przedsiębiorstwach międzynarodowego transportu ciężarowego w 2016 r. i analiza zmian w okresie 2009–2016*, ITS Papers No. 6600/2/ZBE, Warsaw, 30.06.2017.

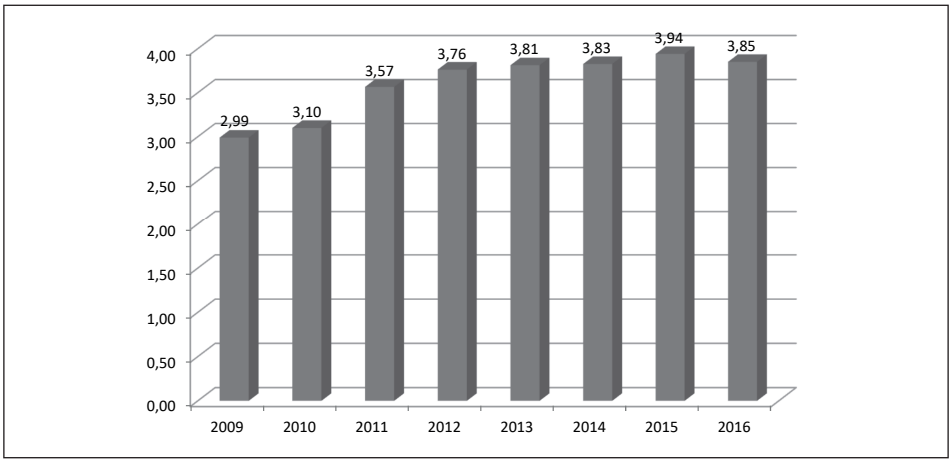

Figure 7. Average costs of 1 vehicle kilometers traveled of mileage in the analyzed enterprises licensed to perform international transport (universal rolling stock with a maximum permissible weight exceeding 12.0 Mg, markets of other EU countries, 2009–2016) [PLN/vehicle kilometers traveled]
Source: own elaboration based on: ITS survey data

Table 2. Weighted average costs 1 vehicle kilometers traveled of the total mileage and according to selected types of costs in 2009–2016 in the analyzed freight transport companies operating the fleet above 12.0 Mg dmc with universal bodies, with a dominant share of transport in relations with markets in other EU countries [PLN /vehicle kilometers traveled]

	2009	2010	2011	2012	2013	2014	2015	2016
Average costs of 1 vehicle kilometers traveled of mileage, including:	2.99	3.1	3.57	3.76	3.81	3.83	3.94	3.85
fuels and consumables	1.13	1.24	1.46	1.48	1.53	1.52	1.47	1.51
repair services, repairs, tires	0.18	0.19	0.21	0.2	0.18	0.16	0.17	0.11
amortization or loss of market value of rolling stock	0.19	0.18	0.14	0.16	0.17	0.15	0.15	0.13
other costs of capital (leasing, credit)	0.33	0.28	0.15	0.17	0.1	0.08	0.07	0.05
remuneration and driver's delegations as well as social security for the employer	0.56	0.56	0.73	0.81	0.9	0.96	1.02	0.95
insurance of means of transport and tax on means of transport	0.11	0.11	0.18	0.24	0.28	0.3	0.37	0.42
road tolls	0.25	0.33	0.48	0.56	0.55	0.54	0.56	0.56
other costs of the company's transport activity	0.23	0.2	0.22	0.15	0.11	0.11	0.14	0.12
number of analyzed companies	63	70	66	48	61	62	61	58

Source: ITS database on costs in freight road transport companies

From the data included in Table 2 among the average costs of 1 vehicle kilometers traveled of mileage in the examined enterprises of international goods transport that mainly operated in relations with markets in other EU countries were dominated by the costs of propelling and operating materials (mainly fuel costs). These costs were, on average, 1.51 PLN/vehicle kilometers traveled in 2016 (around 39.1% in the average cost of 1 vehicle kilometers traveled of themileage).

However, the average unit costs of drivers' remuneration (including the costs of business trips) and the costs of social insurance for the employer in the surveyed enterprises amounted to PLN 0.95 PLN/ vehicle kilometers traveled in 2016 (24.7% of the average cost of 1 vehicle kilometers traveled of the mileage in total). The presented calculation results indicate that the average unit costs of drivers' remuneration (including the costs of business trips) and the costs of social insurance for the employer were systematically increasing during the period covered by the research (in 2009, PLN 0.56 PLN/ vehicle kilometers traveled, 18.7%).

It is clearly seen that in the examined enterprises relatively high and growing from year to year, both nominal and percentage share, the average unit costs of road tolls. In 2016, the cost of road tolls averaged PLN 0.56 PLN/ vehicle kilometers traveled, which represented their share in the average cost of 1 vehicle kilometers traveled of the mileage of 14.6% (in 2009, 0.25 PLN/vehicle kilometers traveled and 8.5% respectively).

Conclusions

The dynamic changes in the share of Polish road transport companies observed in the years 2004–2017 on the international transport market are an important premise for conducting and expanding the scope of research in this area. Analyzes performed on the basis of the results of these studies are helpful in diagnosing the situation and are necessary in political decisions to protect the interests of the Polish side.

ITS is one of the few Polish institutions undertaking attempts to systematically monitor selected segments of the car transport market in Poland, including the production costs of car transport companies. The results of research in the field of costs in road transport, in the face of increasing market competition are interested in state administration entities, which intensively participate in discussions on the issues of transport policy in the EU. Therefore, in this article only selected quantities describing the functioning of Polish road transport in freight transport are indispensable, while they are essential for the work on the EU mobility package.

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CONDITIONS FOR THE FUNCTIONING OF REGULATED COMPETITION ON THE PUBLIC URBAN TRANSPORT MARKET IN POLAND

Abstract

The public urban transport market takes the form of a natural monopoly. In some cases, especially in the situation of supply of a relatively large volume of operation work, the implementation of competitive solutions may result in: improving the quality of services or reducing the cost of vehicle-kilometers. The purpose of the article is to present the determinants of functioning of regulated competition on the public urban transport market in Poland. The conducted analysis focuses on the issue of market openness and access to participation in competitive procedures of private operators. The research covered urban transport markets in cities over 200 000 inhabitants and their characteristics in the scope of: the model of public transport organization (with particular emphasis on the level of opening of markets), the level of competition on the operator market and the method of selecting operators. On the basis of the conducted research, the scope of applying pro-competitive solutions in the scope of contracting services by the largest organizers of public urban transport in Poland was characterized.

Keywords: public transport market, competition, natural monopoly

Introduction

Competition is regulated by one of the models of public urban transport market organization in Poland. This model assumes the selection of operators in competition proceedings, using the public procurement procedure. The limitation of competitive solutions on the public transport market results from the existence of a natural monopoly, in which one entity is able to realize the total demand in a more effective manner than in the case of competition. The natural monopoly

is related to the size of the market, because in the case of low demand, it is difficult to maintain the scale of production effect. The article presents models of functioning of the public transport market in the largest Polish cities (over the population of 200 000). Due to the size of the operational work needed to provide transport services to large urban centers, the use of competitive procedures seems feasible. On the basis of the plans for sustainable development of public transport and data obtained from the organizers of public urban transport, the openness of the market was defined, while the analysis of data on tendering procedures for transport services made it possible to characterize the type and intensity of competition.

1. Organization of the public urban transport market

One of the main factors influencing the choice of the public transport market organization model is the occurrence of a natural monopoly. This structure is defined as a state in which market conditions make it unprofitable for a larger number of enterprises[1]. In the conditions of limited demand, the presence of large entry barriers and due to the production scale effect, one company is able to meet needs in a more cost-effective manner than in the case of competitive impacts. The reduction in the volume of demand takes place primarily in smaller cities, where the public transport network is relatively small, which determines the lower demand for operational work. The existence of a natural monopoly is strongly linked in the case of urban transport with the size of the market[2]. High costs of entering the market, which in the case of transport is equated with a relatively high share of fixed costs, cause that the first supplier in a given market gains a definite competitive advantage over potential competitors[3]. A barrier to market access outside costs may also be preference for the public sector and not allowing private enterprises to the operator market. The organizer of public transport may also be the owner of the operator performing transport. In this situation, the admission of the private entity causes concerns about the proper performance of services. In the case of owner dependencies there is a greater possibility of the organizer's influence on the decisions and actions of the operator than in a situation in which mutual obligations are governed only by the contract for the transport. An additional barrier on the implementation of competitive solutions is the effect of production scale. In the situation of natural monopoly, there is a conflict between cost effectiveness and competition[4]. In terms of model, competition should be conducive to lowering the price, but the lack of the possibility of achieving economies of scale will be conducive to the increase in unit cost. However, in a natural monopoly, the economies

[1] A. Mas-Colell, M.D. Whinston, J.R. Green, *Microeconomics Theory*, Oxford University Press, New York 1995, p. 570.

[2] H. Kołodziejski, *Istota, formy i intensywność konkurencji w komunikacji miejskiej* [in:] *Gospodarowanie w komunikacji miejskiej*, ed. O. Wyszomirski, University of Gdańsk Publisher, Gdańsk 2002, p. 164.

[3] B. Fiedor, *Regulacja państwowa a monopole naturalne*, Prace Naukowe Akademii Ekonomicznej im. Oskara Langego we Wrocławiu 1991, 598, p. 35.

[4] S. Miecznikowski, *Formy oraz intensywność konkurencji w transporcie miejskim* [in:] *Transport miejski. Ekonomika i organizacja*, ed. O. Wyszomirski, University of Gdańsk Publisher, Gdańsk 2007, p. 195.

of scale achieved by the company allow it to satisfy all demand in a given market, at a lower average cost than in any other case[5].

The existence of a natural monopoly, affects the organization of the public transport market and explains the low level of competition. Undoubtedly, along with the intensification of urbanization processes and metropolization in many urban areas, there is an increase in the volume of operational work, which favors the implications of competitive solutions in the selection of the public transport operator. Assuming the separation of the organizer and operator functions (this solution is now common), two solutions are possible[6]:

– a dominant operator controlled by the transport administration;
– competition regulated by the transport administration.

Both forms of organization come to the issue of operator selection. In this regard, the Legislator provides for the following possibilities of contracting public urban transport services[7]: conclusion of a single-source contract (used for orders up to EUR 1 million or 300 000 transport vehicles per year), establishment of an internal entity (based on EC Regulation 1370/2007), conducting competitive proceedings (in accordance with the Public Procurement Law). The organizer has the option of using either an unrivaled mode (internal entity), competitive or hybrid solutions based on the fact that part of the market is reserved for an internal entity and some are subject to competitive proceedings. The privileged position of an internal entity is connected with the following restrictions: it must be the property of local government (100% of shares), it can provide public urban transport services only within the area of one organizer while strongly limiting other commercial activities.

Regulated competition involves the application of the Public Procurement Law[8] (PPL). The selection of the contractor should take place using: equal treatment of contractors, fair competition, impartiality and objectivity, legalism, openness, written procedure and priority of tender procedures. The evaluation and selection of the best offer is based on specific criteria. Initially, along with the introduction of the PPL, it was permissible to use only the price criterion, and as a result the cheapest offer meeting certain requirements won. Over time, the Legislature sought to limit the role of prices and increase the importance of non-price criteria. The Act in its current wording (March 2018) indicates that the share of the price in the bid evaluation process may not exceed 60%. Other criteria with a total weight of 40% have not been defined and their selection and subsequent verification have been passed on to the ordering parties. In the group of price criteria, in general public procurement in Poland (in the period from June 2016 to March 2017) prevailed: the deadline (30%), terms and time of the guarantee (25%) and payment terms (10%)[9]. This list shows

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[5] W.J. Baumol, A.S. Blinder, *Economics: Principles and Policy (12th Edition)*, South-Western Cengage Learning, 2011, p. 220.

[6] R. Tomanek, *Problemy ustalania wielkości dopłat do transportu zbiorowego w warunkach integracji* [in:] *System dopłat do publicznego transportu zbiorowego w komunikacyjnych związkach komunalnych w Polsce*, eds.. R. Janecki, W. Starowicz, PiT Publisher Cracow, Cracow 2009, p. 25.

[7] Act of December 16, 2010 on public collective transport (Journal of Laws of 2011, No. 5, item 13).

[8] Act of 29 January 2004 on Public Procurement Law (Journal of Laws of 2004, No. 19, item 177).

[9] I. Fundowicz, W. Michalski, *Stosowanie kryteriów oceny ofert w postępowaniu o udzielenie zamówienia publicznego* [in:] *Funkcjonowanie systemu zamówień publicznych – aktualne problemy i propozycje rozwiązań*, eds. M. Stręciwilk, A. Panasiuk, Public Procurement Office, Warsaw 2017, p. 13–14.

that the ordering parties marginalize non-price aspects in terms of content, using criteria that are easy to meet and do not directly affect the quality of the order.

In the case of regulated competition on the public transport market, it is assumed that there will be a market verification of unit prices[10], and competition between operators will reduce the unit cost. Over the years, the operator market in Poland has developed significantly and has also become attractive for entities with foreign capital. In spite of this, the following factors limiting the effectiveness of regulated competition are indicated in the literature: limitation of the functions of public transport boards, failure to put in real competition in transport and over-regulation of activities in the sphere of public utilities[11]. In the following parts of the work the organization model and the scope of competition on the public transport market will be discussed in the largest cities in Poland.

2. The model of organization of the public transport market in the largest Polish cities

In accordance with the provisions of the Local Government Act, and the Act on public transport, the collective transport organization was included in the municipality's own tasks. The organization of public urban transport in the area of the commune may be implemented: by the commune in its area, by the commune in its area and in the area of other communes by agreement, by an inter-commune or metropolitan union (to which this commune belongs and entrusted to it by way of resolution competence in the field of organization of public urban transport.

The development of the metropolization process has caused the fact that especially in cases of large urban areas their so-called functional area is considered. The urban functional area includes the core city and the associated urbanized area. These connections take on the character of: transport (travels between work and home), spatial planning and the flow of goods and services of diverse character[12]. The need to provide an adequate public transport offer means that cities must organize public transport in a large area, which results in a high volume of operational work. Table 1 identifies Polish cities with a population of over 200.000 and the model of organization of public urban transport adopted by them.

[10] G. Dydkowski, *Integracja transportu miejskiego*, Publisher of the University of Economics in Katowice, Katowice 2009, p. 187.

[11] K. Grzelec, *Restrukturyzacja miejskiego transportu zbiorowego w Polsce. Od monopolu do… monopolu*, Transport Miejski i Regionalny 2012, 12, p. 35–36.

[12] D. Kociuba, *Miejskie obszary funkcjonalne – wyzwania planistyczne*, Studia Miejskie 2015, 18, p. 41.

Table 1. Characteristics of the organization of public urban transport in cities with over 200 000 residents

City	Numer of residents (1st January 2017)	Organizer of public urban transport	Market model	Volume of annual operating work ordered by the organizer (bus transport) [million vehicle km]
Warsaw	1 753 977	the city's budget unit	domination of the internal entity	115.1 (2016)
Krakow	765 320	the city's budget unit	domination of the internal entity	37.8 (2016)
Łódź	696 503	the city's budget unit	domination of the internal entity	29.7 (2015)
Wrocław	637 683	the organizational unit in the city office	domination of the internal entity	24.0 (2015)
Poznań	540 372	the city's budget unit	domination of the internal entity	33.2 (2015)
Gdańsk	463 754	the city's budget unit	domination of the internal entity	17.2 (2016)
Szczecin	404 878	the city's budget unit	domination of the internal entity	No data
Bydgoszcz	353 938	the city's budget unit	domination of the internal entity	15.2 (2016)
Lublin	340 466	the city's budget unit	domination of the internal entity	No data
Katowice	298 111	the communal union	regulated competition	68.4 (2016)
Białystok	296 628	the city's budget unit	domination of the internal entity	16.6 (2015)
Gdynia	246 991	the city's budget unit	domination of the internal entity	14.3 (2016)
Częstochowa	226 225	the city's budget unit	domination of the internal entity	10.8 (2015)
Radom	215 020	the city's budget unit	domination of the internal entity	9.6 (2016)
Sosnowiec	205 873	the communal union	regulated competition	68.4 (2016)
Toruń	202 521	the city's budget unit	domination of the internal entity	9.7 (2015)

Source: own elaboration based on: Local Data Bank of the Central Statistical Office; Public transport in numbers, 2/15, IGKM 2016; data provided by the organizers and the provisions of relevant plans for sustainable development of public mass transport

The analysis of the organization of public transport in the largest Polish agglomerations indicates that there is a separation of the organizer and operator functions and the domination of the internal entity. In most cases, the city president via a specialized budgetary unit, organizes public urban transport within the city and neighboring municipalities under relevant agreements. The advantage of this solution

is the integration of public transport within the entire functional area of the city. Two areas can be excluded from this trend: the Upper Silesian agglomeration (among others Katowice and Sosnowiec) and the Tri-City agglomeration (Gdansk and Gdynia). In the first case, the organizer of public transport is the Communal Municipal Association which groups 28 municipalities that ceded the organizer's duties to the association (currently the competence of Communal Municipal Association is taken over by the relevant metropolitan union unit: Upper-Silesian Metropolitan Area). The second polycentric area indicated in Table 1 is the Tri-City agglomeration, where despite the independence of Gdansk and Gdynia, in the field of collective transport organization, the Metropolitan Union of the Gulf of Gdansk has been created to perform integrating functions.

The analyzed cities differ in terms of the volume of performed operation work in bus transport (tram transport in this work was omitted due to the clear natural monopoly in this market segment). However, the predominant model of transport organization is entrusting part or all of the market to an internal entity. On the basis of the provisions of transport plans and data obtained from the organizers of public urban transport, the following shares of internal entities in individual markets can be indicated[13]: Warsaw 76%, Krakow 86%, Lodz nearly 100%, Wrocław 88%, Poznań 100%, Gdansk 85%, Szczecin nearly 100%, Bydgoszcz 75%, Lublin 85%, Białystok 100%, Gdynia 75%, Częstochowa 100%, Radom 75%, Toruń 100%. On the basis of the above data, it is possible to indicate the organizers' reluctance to use tender procedures in the process of selecting the operator. In the group of analyzed organizers, the share of private entities reaches a maximum of 25%, in the competition mode, the operators of suburban, agglomeration and night lines are very often selected. Tasks related to internal service of the city are left for municipal operators. In the provisions of plans for sustainable development of public urban transport, in most cases the organizers see the advantages of competition, reflecting the records indicating that in the next few or twenty years approximately 20–30% of the market will be subject to free competition. The results of the tests carried out and the analysis of documents give the basis for indicating the following conclusions:

– the model based on the dominance of the internal entity is most often found in the largest Polish cities;
– in strategic documents, the organizers in the long-term plan to choose an operator in competitive proceedings, but the service of the vast majority of the market will still be outsourced under the entrustment agreement;
– the organizers explain the maintenance of the high share of the internal entity with the insufficiently educated private market and the risk of improper quality of services provided by these entities.

Only in the case of the Communal Municipal Association market, the regulated competition model is fully implemented. The scope of tendering procedures is varied, they concern the operation of one line or packages of several to a dozen or so

[13] For Warsaw, Cracow, Bydgoszcz, Gdańsk, Gdynia, and Radom detailed data for 2016 provided by the organizers, in other cases data based on the provisions of plans for sustainable development of public mass transport and websites of the organizers.

lines of communication. Both municipal entities and private enterprises compete on the market.

3. The scope of competition on the public transport market

The legal framework for competition on the public urban transport market is determined by public procurement law. The tender procedure requires the contracting authority to prepare and place a tender notice, prepare and disclose the specification of essential terms of the order and, if necessary, provide answers to questions asked by potential contractors. As part of the description of the order conditions, in addition to specifying the service, the ordering party indicates how to choose the best offer. This choice is based on specific, measurable and objective criteria. Subsequent amendments to the Public Procurement Law limited the application of the price criterion, in 2014 the necessity to apply a minimum of one non-price criterion, while in the amendment of 22nd June 2016, the price criterion was limited to a maximum of 60% of the share evaluation. In the context of the development of competition on the public urban transport market, two aspects are particularly important: the volume of services ordered in one proceeding and the criteria for selecting the best offer[14].

Determining the volume of services purchased by the organizer in one tender procedure is in contradiction with the effect of economies of scale. On the one hand, a large order allows for a better negotiating position, a long-term contract covering a large package of bus lines is more attractive for operators and will be willing to lower the price. On the other hand, too much concentration of orders reduces the level of competition, and high requirements as to the number of rolling stock units (in order to handle a large order) constitute a barrier to entry. The entry barrier may also be too precisely described (narrowing the number of potential contractors) transport service being the subject of the proceedings. The contracting party faces a dilemma – whether at the specification level specify very high requirements (e.g. age of rolling stock, comfort etc.) while marginalizing non-price criteria for selection of offers, or allow operators having an older fleet park to conduct, rewarding additional points with age and other qualitative rolling stock parameters at the stage of offer evaluation.

The Communal Municipal Association market has been subject to a detailed analysis of the results of tender proceedings, where competitive impacts are the most advanced. In 2016 38 operators operated on the market and the operation of consortia, mainly private enterprises, is a common practice. The tendering procedures usually included one or several dozen lines. Businesses from the former operational plants of the Voivodship Transport Enterprise in Katowice and private entities compete on the bus operators market. The dominant market share at the level of approximately 67% (2016) was owned by the three largest municipal operators. In 2013–2016, a total of 131 orders were awarded as a result of tendering procedures.

[14] See: G. Krawczyk, *Ocena funkcjonowania systemu zamówień publicznych przez operatorów transportu zbiorowego w Polsce*, Zeszyty Naukowe Wydziału Ekonomicznego Uniwersytetu Gdańskiego. Ekonomika Transportu i Logistyka 2017, 74, p. 245–254.

The Communal Municipal Association made the selection of the best offer in the analyzed proceedings dependent on the amount of the price. Until the implementation of the provisions resulting from the amendment of the Public Procurement Law from 2014, the price criterion was 100% of the assessment. In the next period, one non-price criterion – payment terms began to be taken into account. This criterion had a weight of only 5%, which could be obtained in the situation of settling all receivables for a given month within 10 days from the date of receipt of the invoice. As a result of the amendment of the law in 2016, the share of the price criterion for payment terms was reduced, adopting the layout in the assessment process: 60% price, 40% payment deadline. The non-price criteria used in this case are not reflected in the quality of services and are relatively simple to meet. Most of the analyzed documents on the selection of the best offer indicated that the maximum number of points obtained by the bidders in this respect. It should therefore be recognized that the nature of rivalry between operators is only of a price nature. Strong competition exists between private entities. In the analyzed period, only 34 cases were submitted by municipal and private entities. In most cases, orders were awarded to private operators who declared a lower price for the service. Municipal entities won only in 5 tenders, however their market position is very strong. It strengthened as a result of the 2013 procedure, under which the operator of 181 public bus lines was selected. The high volume of orders, implying the need to have a large fleet park, meant that the offer was submitted only by one entity – a consortium of the three largest municipal operators. The example of the Communal Municipal Association indicates that even in the case of regulated competition, the dominant share is held by municipal operators, and ordering a large package of services in one proceeding favors market concentration and limits competition. Despite the increased market concentration as a result of the tender for 181 lines, it should be pointed out that the previous practice of the Communal Municipal Association has allowed for a significant development of the operator market in the national dimension. Many of the operators who start operating in this market successfully compete and handle transports at the request of other organizers.

Conclusions

Competition on the public transport market is carried out under specific conditions. Natural monopoly is an obvious barrier to competition, but in large agglomerations it is difficult to talk about the inability to achieve economies of scale by more than one entity. The example of Communal Municipal Association indicates that regulated competition can be implemented and the operator can be selected on the competition basis. Despite this, in the case of most agglomerations in Poland, there is a clear reluctance to open up the market. If such solutions are already in place, then the tendering process involves outsourcing of less important tasks such as night or suburban lines. The reluctance to open the market may result from the fact that it is convenient to have own operators for whom actual competition could result in a limitation of activity.

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DEVELOPMENT AND SOURCES OF FINANCING OF RAILWAY TRANSPORT INFRASTRUCTURE IN POLAND IN THE YEARS 1990–2016

Abstract

The article focuses on the development of railway transport infrastructure in the years 1990–2016 in Poland and presents sources and ranges of its financing from the funds of the Multi-Year Railway Investment Program for 2011–2015.

Keywords: railway transport, railway transport infrastructure, financing of railway transport infrastructure

Introduction

Transport infrastructure as an element of economic infrastructure plays a role determining the socio-economic development of individual countries and regions of the European Union. On the other hand, the pace of economic development affects the size of investments in infrastructure development and the speed of its modernization in a given area. Therefore, it is necessary to look for solutions that will enable the implementation of infrastructure investments while maintaining a dynamic pace of economic growth. It should be remembered that the lack of investment projects in the area of transport network may be the cause of marginalization of development of particular regions. In connection with that, investments modernizing transport infrastructure should be implemented with the use of the European Union funds in a way that guarantees harmonious development of Poland, while at the same time compensating for backwardness in the discussed topic in the regions that require it.

The aim of the study is to illustrate the level of railway infrastructure development in Poland in the years 1990–2016 and to analyze the level of use of available funds under the Multi-Year Railway Investment Program for 2011–2015 for infrastructure investments in the area of rail transport.

Achieving the objective of the study required the implementation of the research procedure in the context of the information sources used and the methodology for their use. The main source used to write this article was available literature on the subject of logistics infrastructure and publications on the sources of its financing. The statistics of public national and European origin were important for the writing of the work. The conclusions were carried out based on the results of empirically verified logical analysis.

1. Rail transport infrastructure in science

The concept of infrastructure, operating in science and business practice for many years, still has no generally recognized definition, which is why it is not always understood in an unambiguous way[15]. The most capacious definition is that assuming that the infrastructure consists of devices as well as institutions whose existence is necessary for the efficient functioning of the economy and the life of society[16]. For the purposes of this study, let us take a definition of what technical infrastructure is understood as linear and point public facilities located in a given area in a permanent manner that were created by man and form the basis of socio-economic life that results from their functions related to the movement of loads and people (transport) as well as news and energy and water[17].

Railway transport infrastructure, which is the subject of this study, constitutes a component of the logistics infrastructure, which is understood as the infrastructure of all existing modes of transport; we are talking about the linear and point infrastructure that enable the movement of goods and people[18].

Railway infrastructure should be considered on the basis of the Act of 16th November 2016 amending the act on railway transport and some other acts, according to which the railway infrastructure is created by:

– railway tracks (turnouts, track crossings, bumpers, guides, switches, crossings and railway sleepers with fastenings, as well as elements of the railway surface);
– turntables and traversers;
– track bed (embankments and cuttings, drainage systems, masonry trenches, curtain walls, vegetation protecting slopes);
– engineering objects (bridges, viaducts, culverts, tunnels, passages above and below the tracks, retaining walls, strengthening of slopes);

[15] R. Radziejewski, *Infrastruktura a bezpieczeństwo*, Zeszyty Naukowe AON 2013, 3(92), p. 251.
[16] Z. Borcz, *Infrastruktura terenów wiejskich*, Wroclaw University of Environmental and Life Sciences Publisher, Wroclaw 2000.
[17] W. Kozłowski, *Zarządzanie gminnymi inwestycjami infrastrukturalnymi*, Difin Publisher, Warsaw 2012, p. 9–10.
[18] E. Gołembska, M. Szymczak, *Logistyka międzynarodowa*, Poznań University of Economics and Business Publisher, Poznań 2000, p. 58.

– adjustable, railway traffic control devices at once with buildings in which such devices, track-side control devices for safe driving, track brakes, devices for heating turnouts;
– platforms with infrastructure enabling passengers to reach them;
– freight ramps with access roads to public roads;
– technological roads and walkways along the tracks, enclosing walls, hedges, fences, fire-fighting belts, snow curtains;
– rail and road crossings and rail level transitions, including systems to ensure road and pedestrian safety;
– lighting systems;
– electricity processing and distribution equipment for traction power supply;
– land, marked as plots of land, on which there are elements listed in items 1–11 of the Act[19].

Infrastructure, including rail infrastructure, is perceived as a public good. It is characterized by a relatively long period of formation, as well as the technical indivisibility of its objects infrastructure[20].

Technical features attributed to the infrastructure include: high capital intensity, a long period of creation and use, as well as the slow course of the process moral aging, limited opportunities for transformation, spatial immobility and inability to import[21]. Speaking of infrastructure, it should also be remembered that:
– it is important for the economy and society;
– it refers mainly to equipment and service institutions;
– it has important roles in economic and social development;
– the obligation to create and maintain it in the current economic conditions increasingly depends on the private sector, which becomes the owner of the infrastructure[22].

2. Railway infrastructure in Poland

Considerations in the area of railway infrastructure should begin with a discussion of the linear infrastructure, of which railway lines are understood as railway tracks.

Over the last twenty-six years (1990–2016), the length of operated railway lines in Poland has significantly decreased. In 1990, 26 228 km of railway lines were used, while in 2016 it was only 19 132 km (Figure 1). This means that in the analyzed period 7096 km of railway routes were excluded from operation. The reasons for this were many, ranging from the very poor condition of the railway infrastructure and the lack of funds for its modernization, by improper state policy towards

[19] Act of 16 November 2016 amending the act on railway transport and certain other acts (Journal of Laws of 2016, item 1923).
[20] E. Ćpak, *Inwestycje infrastrukturalne wyznacznikiem rozwoju gospodarczego*, Studia Ekonomiczne, Prawne i Administracyjne 2006, 2, p. 17.
[21] M. Ratajczak, *Infrastruktura w gospodarce rynkowej*, Poznań University of Economics and Business, Poznań 1999, p. 32.
[22] R. Radziejewski, *Infrastruktura a bezpieczeństwo…*, p. 253–254.

the railways (e.g. reduction of subsidies to statutory concessions for passenger transport and fossilized and fragmented structure of railway undertakings) and ending with on a significant increase in the length of motorways and other roads, which resulted in a decrease in the interest of passengers in the services of railway carriers due to the proliferation of other means of locomotion.

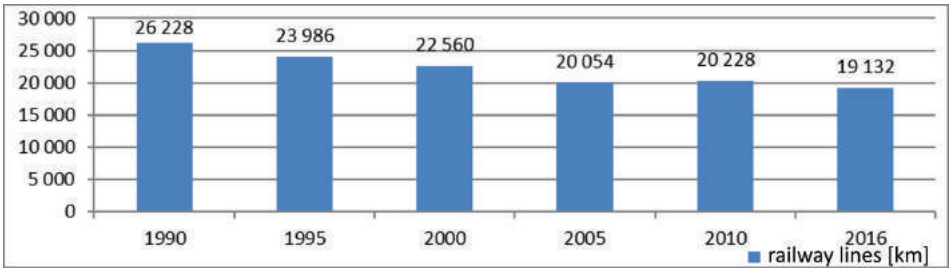

Figure 1. Length of railway lines in Poland in the years 1990–2016
Source: own elaboration based on GUS data: Transport. Operating results in the years 2000, 2005, 2010, 2016 and data contained in the artillery: T. Dyr, P. Wełnic, *Railway transport infrastructure in the European Union and Poland. Railway transport technique 7–8*, The TTS Scientific and Publishing Institute, Radom 2006, p. 25

Out of 19.322 kilometers of railway lines in use, the largest number is located in the Silesian Voivodeship (1964 km), Greater Poland Voivodeship (1878 km) and Lower Silesia Voivodeship (1750 km), while the lowest in the Podlasie Voivodeship (654 km) and Świętokrzyskie Voivodeship (721 km) – Figure 2.

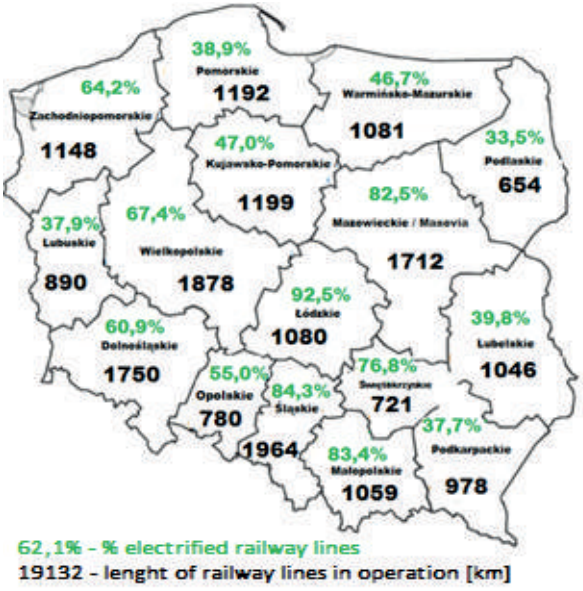

Figure 2. Length of railway lines in use in Poland and % of their electrification (2016)
Source: own elaboration based on GUS data: Transport. Operating results in 2016

The geographical distribution of railway lines indicates that the voivodships of the eastern wall (Podlasie, Podkarpackie, Lublin or Świętokrzyskie Voivodships) are characterized by the smallest length of railway tracks.

In 2016, 11 874 km of operated railway lines were electrified (62.1%). The highest degree of electrification can be found in Łódzkie (92.5%), Silesian (84.3%) and Lesser Poland (83.4%) Voivodships, while the smallest ones in Podlasie (33.5%) and Podkarpackie (37.7%). The share of electrified railway lines in the total length of the operated lines is illustrated in Figure 2. The density of railway lines in Poland is understood as the relation between the length of railway lines expressed in kilometers and the area of Poland is 6.12 km/100 km^2. The highest density of the railway network is marked by Silesian Voivodships (15.9 km/100 km^2), Lower Silesia Voivodship (8.8 km/100 km^2) and Opole Voivodship (8.3 km/100 km^2), while the smallest Podlaskie Voivodship (3.2 km/100) km^2), Lublin (4.2 km/100 km^2) and Warmia-Masurian (4.5 km/100 km^2). The density of the railway network in individual voivodships is presented in Table 1.

Table 1. Density of railway lines in Polish voivodships in 2016

Voivodeship	Area [km^2]	Length of railway lines [km]	Density of railway lines	Voivodeship	Area [km^2]	Length of railway lines [km]	Density of railway lines [km/100 km^2]
Lower Silesian	19 947	1 750	8.8	Podkarpackie	17 846	978	5.5
Kuyavian--Pomeranian	17 972	1 199	6.7	Podlaskie	20 187	654	3.2
Lublin	25 122	1 046	4.2	Pomerania	18 310	1 192	6.5
Lubuskie	13 988	890	6.4	Silesian	12 333	1 964	15.9
Łódzkie	18 219	1 080	5.9	Świętokrzyskie	11 711	721	6.2
Lesser Poland	15 183	1 059	7.0	Warmia--Masurian	24 173	1 081	4.5
Mazovian	35 558	1 712	4.8	Greater Poland	29 826	1 878	6.3
Opole	9 412	780	8.3	West Pomerania	22 892	1 148	5.0
Density of railway lines in Poland = (Length of railway lines in km/Polish area in km^2) × 100% Density of railway lines in Poland = (19 132 km/3 112 679 km^2) × 100 = 6.12 km/100 km^2							

Source: own elaboration based on GUS data: Transport. Operating results in 2016

The efficient functioning of rail transport is possible with the existing available railway infrastructure, which is operated by modern means of transport. Currently, Polish railways have 1814 electric locomotives, 2190 diesel locomotives, 1123 electric multiple units and 157 diesel multiple units. In addition, there are 87 598 freight wagons in use and 6975 passenger cars (Table 2).

Table 2. Railway transport means in Poland in the years 2005–2016

Specification	Year		
	2005	2010	2016
Electric locomotives	1 856	1 905	1 814
Diesel locomotives	2 520	2 358	2 190
Electric traction units	1 341	1 213	1 223
Diesel multiple units	91	–	157
Freight wagons	103 234	89 270	87 598
Passenger wagons	8 881	7 885	6 975

Source: own elaboration based on GUS data: Transport. Operating results in the years: 2005, 2010, 2016

The number of means of rail transport decreases year by year. This applies not only to locomotives, especially diesel, but also wagons, both freight and personal. Only in the case of diesel traction units, an increase in the number of units operated is observed. This is due to the fact that they are used on non-electrified lines as well as in local passenger transport. Their usefulness is determined by the fact that they are faster than warehouses run by electric locomotives.

The availability of rail transport means determines the amount of work they do. In 2016, 222 523 tons of cargo were transported by railway means of transport, which in terms of ton-kilometres gives a value of 50 649.50. In the same year, the railways transported 291 981 passengers, which corresponds to 1917.60 million passenger-kilometers (Table 3).

Table 3. Work performed by rail transport in Poland over the years 2005–2016

Specification	Year		
	2005	2010	2016
Cargo transport (ton)	269 553	216 899	222 523
Cargo transportation (mln ton-kilometre)	49 972.1	48 706.90	50 649.50
Passenger transport (passenger)	258 019	261 314	291 981
Passenger transport (mln passenger-kilometre)	18 155.1	17 921.1	19 174.60

Source: own elaboration based on GUS data: Transport. Operating results in the years: 2005, 2010, 2016

3. Financing of railway infrastructure in Poland

The financing of railway infrastructure in Poland is multifaceted. The basic source of support is the state budget, which carries out investment projects on the railway based on the Multi-Year Railway Investment Program for the years 2011–2015, which was now replaced by the National Railway Program until 2023.

Infrastructural projects may be implemented with the involvement of the infrastructure manager and local government funds, as well as funds obtained as part of Poland's presence in the European Union.

This part of the study will illustrate the use of public funds allocated for infrastructure investments in the area of rail transport planned for implementation under the Multi-annual Railway Investment Program for the years 2011–2015.

As part of the Multi-Year Railway Investment Program for the years 2011–2015, a total of 22 732 948 000 were spent. zlotys for the purpose of investment works. Of this amount, most funds were distributed in 2015 (Figure 3).

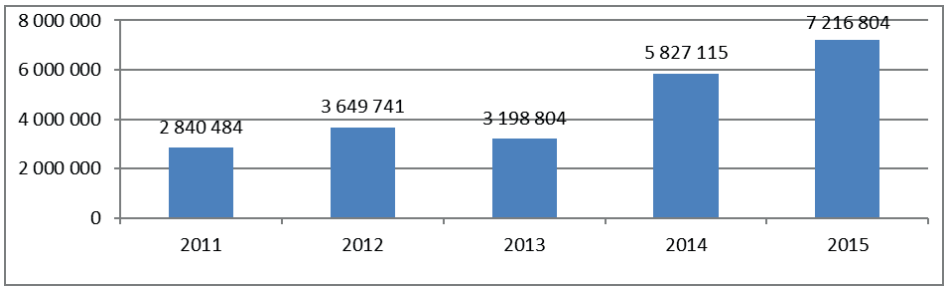

Figure 3. Implementation of the Multi-Year Railway Investment Program for the years 2011–2015

Source: own elaboration based on: the Report on the implementation of the Multi-annual Railway Investment Program for 2015 (Ministry of Infrastructure)

The funds available under the Multi-Year Railway Investment Program for the years 2011–2015 were spent under the Operational Program Infrastructure and Environment (OPI & E), Regional Operational Programs (ROP) and other programs (e.g. Railway Fund and TEN-T).

Table 4. Financial implementation of the Multi-Year Railway Investment Program for 2011–2015

Specification	2011	2012	2013	2014	2015	Total	%
Operational Program Infrastructure and Environment (OPI & E) [PLN]	1 142 675	2 280 477	1 676 221	4 394 800	5 861 211	15 355 385	67.5
Regional Operational Programs (ROP) [PLN]	466 428	317 681	318 988	197 879	222 854	1 523 830	6.7
Other programs [PLN]	1 231 381	1 051 583	1 203 595	1 234 436	1 132 739	5 853 734	25.7

Source: own elaboration based on the Report on the implementation of the Multi-annual Railway Investment Program for 2015 (Ministry of Infrastructure)

In the years 2011–2015, investments amounting to PLN 15 355 385 were carried out as part of the Operational Program Infrastructure and Environment (OPI & E), which constituted 67.5% of expenses realized in this period as part of the Multi-Year Railway Investment Program for 2011–2015 (Table 4).

Considering the implementation of tangible indicators of the analyzed program (2011–2015), it should be noted that in the analyzed period 2960 km of railway lines and 4746 km of track and main tracks were modernized. In addition, 1813 different engineering structures, 2442 intersections and 890 platform edge pieces were modernized and built. The degree of material investment in particular years is illustrated in Table 5.

Table 5. Tangible performance of the indicators of the Multi-Year Railway Investment Program for the years 2011–2015

Indices	Year					
	2011	2012	2013	2014	2015	Total
Railway lines [km]	506	556	796	742	360	2960
Main tracks [km]	734	850	1241	1235	686	4746
Engineering objects	214	413	646	8755	540	1813
Crossroads	207	296	390	714	835	2442
Platform edges	105	138	171	291	185	890

Source: own elaboration based on: the reports on the implementation of the Multi-Year Railway Investment Program for the years 2011–2015 (Ministry of Infrastructure)

The investment projects listed in Table 5 are not the only ones implemented under the Multi-annual Railway Investment Program for 2011–2015. Currently, the continuation of the Multi-Year Railway Investment Program is the National Railway Program (NRP), which assumes the investment of PLN 67 billion in railway infrastructure by 2023. This means that within six years (2018–2023) Poland will spend 10 billion PLN a year in the development of rail infrastructure. It is an organizational and technical challenge, the success of which can change the image of the railway in Poland. The plans assume the creation of a High-Speed Railway, which are to be a revolution in domestic public transport, and in relation to the existing infrastructure, guarantee the maintenance of technical parameters of newly modernized railway lines, as well as the elimination of maintenance arrears. These projects are to lead to shortening the travel time and the purchase of a new rolling stock is to ensure a higher quality of services.

Conclusions

The development of railway infrastructure is an important factor determining the socio-economic development of the regions, but it is also a factor facilitating the implementation of the occupational mobility of the society. In the opinion of The World Economic Forum, infrastructure, including rail infrastructure, is one of the twelve pillars that determine the competitiveness of economies of individual countries, and at the same time it is counted among four basic factors of their development. The condition of transport infrastructure affects the location of economic activity in individual regions of the country. The high level of railway infrastructure development "reduces distances" between particular geographic regions of the country and has a positive effect on the integration of the domestic market, which is included in the global economy system. Infrastructure has a significant impact on economic growth, as well as reducing economic inequalities

and eradicating poverty. It combines academic research centers, schools, residential districts[23], as well as jobs and recreation[24].

In the coming years, the country's effort should be directed at raising funds for the development of railway infrastructure, as well as on effective and rational spending of acquired funds. It is important to modernize the railway infrastructure in the regions that particularly need it; this applies mainly to eastern voivodships, which will be able to change the state of the railway infrastructure thanks to the measures of the Eastern Poland Program 2014–2020, which under the Supra-regional Railway infrastructure will provide over 330 million euro for investment activities.

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THE INFRASTRUCTURE OF ROAD TRANSPORT IN POLAND IN SHAPING THE STATE SECURITY

Abstract

The infrastructure of road transport, as one of the elements of the country's transport system, has a significant impact on the implementation of all kinds of transport taking place within the particular transport branch. Current quantitative and qualitative nature of individual infrastructural elements occurring in Poland, as well as the possibility of their further development are of great importance in shaping multidimensional security of the Republic of Poland.

Keywords: infrastructure, road transport, security, Poland

Introduction

One of the determinants of modern country security is a well-functioning transport system that allows people and cargo to move around during peace, crisis and war. Among its elements, transport infrastructure plays an important role, including the commonly used road transport infrastructure. How it shapes Poland's security is conditioned mainly by the condition of its individual elements, considered in terms of quantity and quality. The degree of implementation of emerging infrastructural innovations is also significant. The high level of infrastructure development of the country and innovation are identified with the readiness to respond to emerging needs, challenges and threats, as well as with the guarantee of the freedom to implement a number of processes directly or indirectly related to transport.

The purpose of this article is therefore to show the role of road transport infrastructure in shaping the security of the country, perceived through the prism of military security, ecological security and road traffic security. Thanks to the identification of problems in the area of road transport infrastructure and the indication

of priority actions, it is possible to develop the infrastructure of the transport branch described and, consequently, to improve the security of the Republic of Poland.

1. The role of road transport infrastructure in shaping the security of the country

When considering the transport infrastructure, it is worth emphasizing the role of the indicated transport branch. Thanks to many advantages, such as spatial availability, the possibility of transporting door to door or relative speed and flexibility, road transport has become widely used. It satisfies a number of needs related to the movement of persons and cargo during peace, crisis and war, as well as enabling efficient and effective functioning of the economy on a global and national scale. Proper implementation of transport tasks depends largely on the condition of the transport system. Its efficient operation is therefore influenced by all the elements that create it, i.e. means of transport, transport infrastructure, human capital, principles, rules as well as those taking place between individual components of dependencies and relations[1].

Although the literature provides different interpretations of the term infrastructure, for the purposes of this article it was assumed that transport infrastructure is made of buildings permanently associated with the area, forming the basis of transport lines and points, and also contribute to the social and economic development of a given country or region[2]. The integral elements of the transport infrastructure are now innovative tools that use information and communication technologies (ICT) to manage transport, including transport infrastructure management, the so-called intelligent transport systems (ITS)[3]. In accordance with the provisions of the Transport Development Strategy until 2020 (with a perspective until 2030), the following are mentioned among the directions of intervention in the framework of road transport: supporting the development of intelligent transport systems, contributing to increasing the efficiency of using existing road infrastructure and improving road safety[4]. It can therefore be concluded that "intelligent" roads, vehicles, parking lots and signs will develop intensively, and intelligent transport systems are the future in the field of transport[5]. At the same time, it should be emphasized that the development of individual infrastructural elements of road transport should not only consist in creating an integrated

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1 E. Dębicka, T. Jałowiec, *Zapewnienie ciągłości działania systemów transportowych*, Prace Naukowe Politechniki Warszawskiej. Transport 2016, 111, p. 36.

2 K. Wojewódzka, R. Rolbiecki, *Infrastruktura transportu. Europa, Polska – teoria i praktyka*, PWN, Warsaw 2018, p. 17.

3 *Ibidem*.

4 *Transport Development Strategy until 2020 (with prospects until 2030)*, Ministry of Transport, Construction and Maritime Economy, Warsaw 2013, p. 70, https://www.gov.pl/documents/905843/1047987/Strategia_Rozwoju_Transportu_do_2020_roku.pdf/ead3114a-aac7-3cdd-c71d-7f88267ce596 (access: 9.03.2018).

5 J. Mikulski, *Budowa i rozwój inteligentnych systemów transportowych*, Współczesne Systemy Transportowe 2015, 1, p. 12, http://www.wydawnictwo.wst.pl/uploads/files/5eac1f18e9f40547516076bdf52cc531.pdf (access: 9.03.2018).

transport network or increasing capacity, but also in striving to improve safety[6]. For example, the construction and modernization of the linear and point transport infrastructure in Poland should take into account the requirements of using electric cars (striving to improve the environmental safety of the country) or the latest global results in the elimination of technical and organizational causes of road accidents (striving to improve transport safety, road traffic safety).

The very concept of security is defined in many ways, including as a state of non-threat[7] or a state that gives a sense of confidence and guarantees its maintenance and a chance for improvement[8]. However, an in-depth analysis of the various interpretations of this term allows to conclude that in addition to reducing threats, security should be seen through the prism of the possibility of free development as well as ensuring prosperity. What is more, the contemporary dimension of security cannot be identified only with the assurance of internal order or territorial integrity, which is why in the literature there are different types (divisions, areas) of security, among others classification taking into account military, economic (energy, raw materials, food, economic), political, ideological, social, cultural, demographic, humanitarian, health, ecological, scientific and technical security[9]. It should be said that country security should be perceived as multidimensional – the ambiguity and even ambiguity of the concept considered from the point of view of researchers of security sciences, political science, international relations and others, on the one hand demonstrates its enormous content and subject-matter complexity and, on the other hand, about the constant need to conduct interdisciplinary research on this multifaceted and multidimensional research category[10]. When carrying out safety considerations with regard to road transport and its infrastructure, it should be noted that they can also cover many aspects. Because it is impossible to describe all of them, the following parts of the article will only present examples of connections between the infrastructure of road transport occurring in the territory of the Republic of Poland and safety in the military, ecological and road safety aspects. The presentation of the role of road transport infrastructure in shaping the security of the state will be possible by showing the current state of selected infrastructure elements and identifying problems related to their use and development. Due to the extensive scope of the problem, it was also considered appropriate to narrow the scientific considerations only to selected components of the infrastructure of the described transport branch.

Some of the problems in the area of road transport infrastructure arise from the very characteristics of the infrastructure. For example, a long period of its formation is associated with the freezing of expenditures that are spent on its construction. What's more, the effects of the works are not immediate – sometimes it is necessary to wait even a dozen or so years for the final commissioning of the facility.

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[6] M. Sitarz, *Zintegrowany system i środki transportu w Polsce*, Silesian Technical University, Katowice 2009, p. 36.

[7] https://sjp.pwn.pl/slowniki/bezpiecze%C5%84stwo.html (access: 9.03.2018).

[8] *Słownik terminów z zakresu bezpieczeństwa narodowego*, eds. J. Kaczmarek, W. Łepkowski, B. Zdrodowski, National Defence Academy, Warsaw 2008, p. 14.

[9] J. Gryz, *Bezpieczeństwo państwa. Zarys problematyki*, National Defence Academy, Warsaw 2016, s. 21.

[10] *Wielowymiarowość kategorii bezpieczeństwa: wymiar społeczny*, vol. 1 [in:] eds. K. Sygidus, P. Łubiński, Denys Svyrydenko, Bookmarket Publishing & Editing, Olsztyn–Warsaw–Kiev 2018, p. 5.

In addition, infrastructure investments are often unique, implemented in various conditions, related to the area, which causes that unforeseen technical problems occur in the course of implementation, resulting in economic problems and, as a result, the time of infrastructure projects often exceeds the previously planned[11].

Another issue that is a significant obstacle to the proper functioning and development of infrastructure may be its capital intensity, and, consequently, all issues related to its financing. Poland can use various sources of financing for the construction and modernization of roads, including the state budget or the National Road Fund (including also funds from the European Union). The "Public-Private Partnership" (PPP) also offers many opportunities, an example of which is a part of the A1 motorway, running from the Gdansk area to Toruń, 152 km long, which was implemented between the State Treasury and the company Gdansk Transport Company[12]. Nevertheless, despite the huge expenditures for the development and modernization of the Polish transport infrastructure, this area can still be considered as underinvested, primarily due to the large number of investments necessary to carry out and high costs of their implementation.

Many infrastructural difficulties occurring in Poland are also connected with the quantitative and qualitative status of the car transport infrastructure and the deployment of the road network. The new administrative system introduced in 1999 influenced the division of the national public road network, distinguishing the following categories: national roads, voivodship, county and commune roads[13]. At the end of 2015, the length of all roads in Poland was 419 636.4 km, of which 290 919.1 km were roads with a hard surface. Table 1 presents information on the managers of the aforementioned public roads category in Poland and their length at the end of 2015.

Table 1. List of public roads in Poland and their administrators

Category of public road	Length of roads – on 31st December 2015 [km]	Road administrators divided into categories
National roads	19 292.8	General Director of National Roads and Highways [excluding sections of national roads within cities with county rights and sections of toll motorways whose manager (after signing a concession agreement) becomes a concessionaire
Voivodship roads	29 108.6	voivodship board
County roads	125 092.3	county board
Commune roads	246 142.7	commune head (mayor, city president)

Source: study based on: https://www.gddkia.gov.pl/pl/a/6846/zarzadzanie-drogami-publicznymi (access: 3.03.2018); *Transport – results of operations in 2016*, Central Statistical Office, Warsaw 2017, p. 51, https://stat.gov.pl, 9/03/2018 (access: 9.01.2018)

[11] K. Wojewódzka-Król, *Problemy rozwoju infrastruktury transportu w Polsce w świetle tendencji unijnych*, Logistyka 2010, 3, p. 18, https://www.logistyka.net.pl/bank-wiedzy/logistyka/item/download/1389_57a-5f907aa03e4e932034fef81994504 (access: 16.02.2018).

[12] http://www.ndi.pl/ppp/autostrada-a1 (access: 17.02.2018).

[13] Annex to Resolution No. 105/2017 of the Council of Ministers of 12 July 2017 amending the resolution on establishing a long-term program under the name "National Road Construction Program for 2014–2023 (with a prospect until 2025)", http://mib.gov.pl/2-program_budowy_drog_krajowych.htm (access: 20.02.2018).

The distinction of administrators clearly defines who is responsible for a particular road, its maintenance, repairs and further development. It should also be noted that within the limits of cities with county rights (65 cities), the functions of the administrator of all public roads (except for motorways and expressways), i.e. national, provincial, county and municipal roads, are fulfilled by the management of the city[14].

In Poland, at the end of 2015, the average density of hard-surfaced roads was 93 km/100 km^2, while this density cannot be considered as homogeneous across the country. For example, in the Warmian-Masurian Voivodeship the density of roads with a hard surface (at the end of 2015) was about 55.2 km/100 km^2, while in the Silesian Voivodeship it was 175.5 km/100 km^2[15]. The technical condition of road surfaces may also be a source of a number of difficulties. For example, the state of national roads, managed by the General Directorate of National Roads and Highways, at the end of 2015 in 60.6% was assessed as satisfactory, but 25.3% were roads with a warning state, and 14.1% – roads with a condition critical. At the end of 2016, there were 51.8% of roads with satisfactory pavement condition, but the decrease in relation to the previous year is largely a consequence of methodological changes as well as more precise measurement procedures and technologies, which have been implemented by General Directorate for National Roads and Highways since the beginning of 2016[16]. Another characteristic problem for the national road network in Poland is their non-adaptation to the load transfer of 115 kN/axle. Not without significance is the fact that many roads in Poland with high traffic flows through urban areas. In addition, although the national road network in Poland accounts for only 4.6% of public roads in total, it transfers as much as 60% of traffic[17]. That is why it seems so necessary to systematically modernize the above-mentioned infrastructural elements, as well as to expand them.

Highways and expressways, which are characterized by the highest technical standard, remain the most important roads for national security. However, it is worth emphasizing that currently there is a lack of a coherent network of expressways in Poland[18]. At the same time, it should be added that as of March 2018, 1638.45 km of highways and 1807.3 km of expressways were built in Poland, which gives a total length of 3445.75 km of expressways[19]. According to the Regulation of the Council of Ministers of 19th May 2016 amending the regulation on the network of motorways and expressways, approximately 7650 km of expressways will be created in Poland, including about 2000 km of motorways[20].

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[14] https://www.gddkia.gov.pl/pl/a/6846/zarzadzanie-drogami-publicznymi (access: 3.03.2018).

[15] *Transport – results of operations in 2016*, Central Statistical Office, Warsaw 2017, p. 51, https://stat.gov.pl (access: 9.01.2018).

[16] M. Radzikowski, G. Foryś, M. Bogdaniuk, *Raport o stanie technicznym nawierzchni sieci dróg krajowych na koniec 2016 roku*, https://www.gddkia.gov.pl/userfiles/articles/r/raporty_18751/Raport%202016.pdf (access: 13.03.2018).

[17] Annex to Resolution No. 105/2017…

[18] *Ibidem*.

[19] https://www.gddkia.gov.pl/pl/926/autostrady (access: 13.03.2018).

[20] Regulation of the Council of Ministers of 19 May 2016 amending the regulation on the network of motorways and expressways (Journal of Laws of 2016, item 784).

In summary, the road transport infrastructure, as one of the elements of the country's transport system, enables meeting various needs related to relocation and thus forms the basis for socio-economic development. However, at the same time the unsatisfactory condition of its individual elements may have a negative impact on the security of the state, hence the need to strive for its continuous development.

2. The development of road transport infrastructure in Poland from the perspective of national security

In the deliberations under consideration it is worth considering what determinants have a major impact on the development of Polish road transport infrastructure. The analysis of scientific and journalistic sources made it possible to identify the following key development factors:

- multi-channel financing of infrastructure investments (including noticing the necessity of cooperation between the public and private sectors);
- using the development of innovations in the construction and modernization of transport infrastructure facilities, as well as the implementation of new technologies;
- continuity of investment implementation regardless of political changes;
- making decisions in the field of modernization and development of the car transport infrastructure by educated staff based on extensive analyzes in the scope of determining priority activities and optimal ways of their implementation.

In addition to identifying the determinants of the development of Polish road transport infrastructure, it is worth considering what activities in the scope of its extension, modernization, implementation of new organizational, legal and technological solutions can shape the security of the state. The examples presented below refer to the improvement of military and ecological safety and road traffic safety.

The quantitative and qualitative condition of the road transport infrastructure should enable the implementation of a number of transport tasks not only during the uninterrupted functioning of the country, but also when different types of challenges or threats start to affect the country's transport system, or if there is already an armed conflict in the country. Therefore, the defensive preparations of the country are being carried out, defined as a process implemented by all entities of the state defense system, covering the entirety of planning, organizational and material-financial undertakings aimed at preparing forces and means and procedures of these entities to ensure survival the state and its citizens in the event of an external threat to security and during the war[21].

One of the many areas of defensive tasks implementation by the state defense system entities is the preparation of transport and transport infrastructure for defensive needs. It should be pointed out that the preparation of road transport infrastructure includes: preparation of public roads for use during the war, construction of detours of selected cities and road junctions, reduction of single-level

[21] M. Kuliczkowski, *Pozamilitarne przygotowania obronne w Polsce. Próba systematyzacji procesualnych oraz funkcjonalnych aspektów przygotowań*, National Defence Academy, Warsaw 2016, p. 29.

road intersections with railway lines characterized by high frequency of traffic, maintenance of existing journeys and collision-free crossroads, construction of so-called bridges duplicating, construction and maintenance of road border crossings, construction and modernization of roadside airport sections[22].

The effects of implementing the above actions can affect the flow of people, equipment, supplies etc. during a possible crisis or war, but also cause beneficial changes in the everyday use of roads in time of peace.

It is worth mentioning that at the beginning of 2018, the President of the Republic of Poland signed the amendment to the Act on Public Roads, concerning roads of defensive importance. These roads are designated in time of peace, but they can be used both during peace, crisis and war in order to carry out transports essential for the defense of the country and fulfillment of allied obligations. Until now, the roads with a defensive significance were mainly highways and expressways. The legislative changes introduced make it clear that currently defensive roads can belong to all road categories[23]. Therefore obstacles of defensive importance will be county and commune roads, access sections to airports or seaports, polygons, material depots or special objects, as long as they are deemed necessary for the movement of the Polish Armed Forces and allied troops[24]. This means that tasks related to the reconstruction and modernization of roads of defensive importance, carried out as part of state defense preparations, will be able to be financed from the state budget as part of defense expenditures[25]. This solution will avoid a situation where, for example, a particularly important road for the future transport of heavy equipment (e.g. tanks on low-loader sets) is not adjusted, while local managers do not have the funds for such investments. It is also worth adding that in a situation when a reconstruction of a county road with a defensive significance is planned, its manager will be able to report the desire to build a sidewalk or bicycle path, if he participated in its financing[26].

Apart from the area related to defense preparations, the car transport infrastructure can also shape ecological safety. Road transport is a branch that has a very negative impact on the natural environment, primarily through the emission of pollutants into the atmosphere, however, solutions that reduce these phenomena are increasingly being used. An example of this may be the use of intermodal transport on a larger scale or the use of eco-driving rules by drivers, but particular importance is attributed to emerging technological and infrastructural innovations. The development of the electric car market entails the need to develop appropriate charging solutions. According to the act on electro mobility and alternative fuels adopted at the beginning of 2018, nearly 6400 vehicle charging points by electricity will be created in Poland by 2020[27]. Referring to the linear infrastructure of the described

[22] See the Regulation of the Council of Ministers of February 3, 2004 on the conditions and manner of preparation and the use of transport for defense purposes of the state, as well as its protection during the war, and the properties of organs in these matters (Journal of Laws 2004 No. 34, item 294).

[23] The Act of 21 March 1985 on public roads (Journal of Laws 1985 No. 14, item 60).

[24] Justification of the draft act amending the act on public roads, http://www.sejm.gov.pl/sejm8.nsf/druk.xsp?nr=2038 (access: 13.03.2018).

[25] The Act of 21 March 1985 on public roads (Journal of Laws 1985 No. 14, item 60).

[26] http://www.polska-zbrojna.pl/home/articleshow/24227 (access: 14.03. 2018).

[27] http://www.me.gov.pl/node/28115&quot (access: 10.03.2018).

transport branch, it is worth pointing to the innovative technology of wireless charging of electric cars while driving, which is currently under testing. Dynamic charging of car batteries would be possible thanks to the installations located in the road surface. Spread of such a method could become another turning point in the development of motorization, and at the same time a solution supporting proecological trends and an element affecting the country's environmental safety[28].

Another important point in the deliberations under consideration is road traffic safety. Although in Poland the number of people killed and injured in recent years has decreased (for example, since 2007 the risk of death as a result of an accident has been reduced by 46%), we still rank among countries (such as Romania, Bulgaria, Latvia) with the worst statistics on road accidents and their consequences[29]. Among the various causes of road accidents, the occurrence of irregularities in the road transport infrastructure is also mentioned, bearing in mind both technical and organizational deficiencies. However, it should be noted that the influence of road factors on traffic safety is given as a reason for only 2–4% of events. At the same time, detailed studies carried out by experts from European countries lead to the conclusion that inadequate road infrastructure indirectly and directly contributes to the creation of up to 30% of accidents[30]. Therefore, it is necessary to expand and modernize the road network and at the same time the remaining elements included in the line infrastructure of the indicated transport branch, including the implementation and spreading innovative solutions. An example of this is the introduction of staple speed measurements, speed bumps with speed radar, which only come out when the car is driving at too high a speed or intelligent pedestrian crossings based on motion sensors and radio signals.

The above examples allow to state that country security can be perceived through the prism of particular types of security, which allows to precisely determine the directions of further development of road transport infrastructure and to take specific implementation measures.

Conclusions

This article presents the role of the national road transport infrastructure from the perspective of ensuring Poland's security, analyzed in terms of the criteria adopted by the author, as well as the possibilities for its further development. Among the identified problems occurring in the infrastructure of the described transport branch, among others for a large percentage of national roads in poor or

[28] http://wgospodarce.pl/informacje/36882-renault-bezprzewodowe-ladowanie-rozwiaze-problem--zasiegu-aut-elektrycznych (access: 10.03.2018).

[29] *The state of road traffic safety and activities carried out in this area in 2016*, the Secretariat of the National Road Safety Council, the Ministry of Infrastructure and Construction, http://www.krbrd.gov.pl/files/file_add/download/407_stan-bezpieczenstwa-ruchu-drogowego-oraz-dzialania-realizowane-w-tym-zakresie--w-2016-r..pdf, p. 10 (access: 9.03.2018).

[30] M. Szruba, *Wpływ infrastruktury drogowej i oświetlenia na bezpieczeństwo ruchu*, Nowoczesne Budownictwo Inżynieryjne, May–June 2017, http://www.nbi.com.pl/assets/NBI-pdf/2017/3_72_2017/Pdf/16_Wplyw_infrastruktury_drogowej_i_oswietlenia_na_bezpieczenstwo_ruchu.pdf (access: 9.03.2018).

unsatisfactory condition, unsuitable for carrying 115 kN/axle load or lack of a consistent network of expressways. Among the main factors determining the development of infrastructure in this mode of transport, the following were considered the most important: multi-channel financing, implementation and spread of innovations, participation in the planning and decision-making process of experienced staff, as well as continuity of implementation of the undertaken investments. The last part of the article presents examples of connections between transport infrastructure and country security. The issues related to defense preparations, adaptation of proecological solutions and implementation of elements reducing road accidents and their tragic consequences were also recalled here. The author acknowledges that the work can be the basis for further research in the area of road transport infrastructure in Poland, as well as be helpful in identifying elements affecting modern state security.

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JOINT VENTURES ON THE AIR TRANSPORT MARKET – A NEW DIMENSION OF COOPERATION

Abstract

Strategic partnership based on cooperation, as part of strategic alliances and other cooperation agreements, has its history in the aviation sector. The processes of cooperation and consolidation decide about the competitiveness of entities from this sector in the global aviation market. This applies not only to airlines, but also airports constituting the infrastructure entities of this sector. The article points to new trends in the construction of partnerships, blurring relations in alliances and wider cooperation of airlines based on joint venture agreements. The development of joint ventures in aviation changes the structure of the aviation market, the conditions of competition, and also changes the strength and depth of existing cooperation within alliances. It re-evaluates their importance in obtaining competitive advantages on the market.

Keywords: air transport, joint ventures, consolidation, cooperation

Introduction

Consolidation and cooperation trends intensified on the aviation market with the development of globalization processes. The extension of liberalization trends, limiting the forms and scope of country interference in the functioning of the aviation market, deregulation and ownership transformation are the main aspects of changes and conditions for the functioning of aviation sector entities. The impulse of global changes in this area was the deregulation of the aviation market in the USA[1]. Since the early 1990s, "Airlines Business" has published

[1] More on this subject, see: E. Marciszewska, *Globalizacja sektora usług transportu lotniczego*, Monographs and Studies, No. 493, OW SGH, Warsaw 2001.

research reports on the development of strategic agreements – alliances made in the aviation sector. These alliances were treated as a response to changing the conditions of competition on the market. It should be noted, however, that changes in the conditions of competition were at the same time the cause and effect of the development of alliances. The subject matter of alliances was also devoted to a lot of space in the Boston Consulting Group[2], in the works of J. Gallacher, J. Feldman, J. Burton, P. Hanlon or E. Marciszewska[3]. All the researchers at the time stressed that the main motive for alliances was to avoid destructive competition and replace it with cooperation of competitors, which also gives the opportunity to gain economies of scale, range, concentration and experience.

Air transport, from the essence of its activity, belongs to the global sectors, because, as M.E. Porter emphasizes: "the global sector is such a sector in which the strategic situation of competitors in the core regional markets depends to a large extent on their global situation"[4].

Over the past 20 years, when the evolution of the entire aviation sector and its entities towards global action strategies has been observed, the forms, tools and methods of competing in this sector changed as a result of market liberalization. Still, the main carriers from the US, Asia or the European Union do not allow and probably will not allow for a long time to the situation where "foreign", i.e. entities from other countries, will take full control over their lines. On the global market in the last 5 years, the configuration of airline participation in 3 major alliances, i.e. Star Alliance, Oneworld, Sky Team, has basically not changed. We have been observing the development since 1997, that is for 20 years. Established in 1997, Star Alliance currently has 28 carriers, Oneworld (established also in 1998) 15, and Sky Team (founded in 2000) 20. They support together over 60% of the aviation market. The potential of these groups is illustrated in Figure 1 and 2.

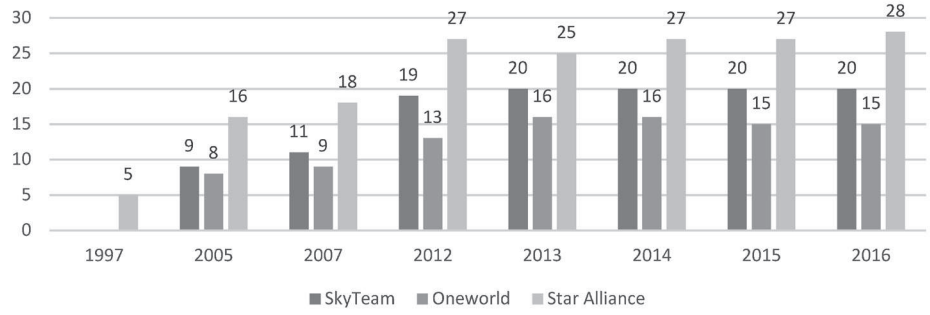

Figure 1. Number of air carriers in major aviation alliances in 1997–2016
Source: D. Tłoczyński, *Aviation Market 2017. Report*, Tourism News, Warsaw 2017

[2] *Marriages made in heaven?*, The Avmark Aviation Economist, Boston Consulting Group 1996.

[3] J. Burton, P. Hanlon, *Airline alliances: cooperating to compete?*, Journal of Air Transport Managements 1994, 4; P. Hanlon, *Global Airlines, competition in a Transnational Industry*, Butterworth Heinemann 1996; E. Marciszewska, *Globalizacja…*

[4] M.E. Porter, *Strategia konkurencji. Metody analizy sektorów i konkurentów*, PWE, Warsaw 1992, p. 270.

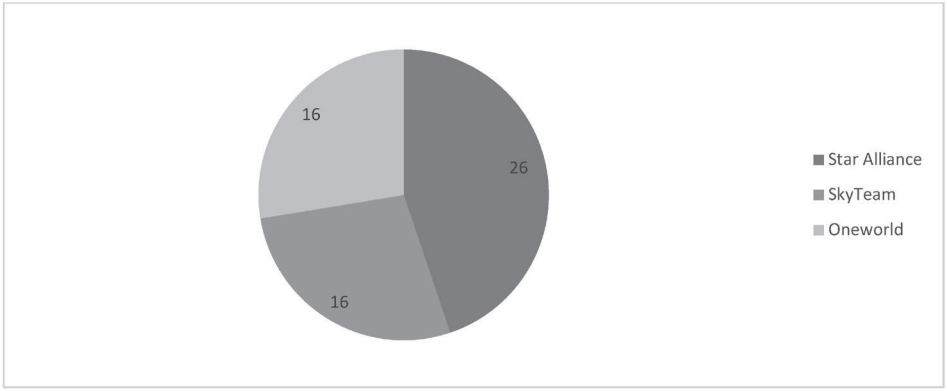

Figure 2. Participation of the largest airline alliances in 2016 according to the availability of seats
Source: D. Tłoczyński, *Aviation Market 2017. Report*, Tourism News, Warsaw 2017

1. Archetypes of strategic management from the perspective of the aviation sector

In the literature concerning management, three universal archetypes of strategic management are mentioned:
– product life cycle;
– economies of scale, scope benefits and learning curve;
– dimensions of the rational decision-making process[5].

From the point of view of the aviation sector, considerations regarding the economies of scale, scope and curve of experience are particularly useful. They have a similar impact on management effectiveness and are the most useful archetype in strategic management in the new environment and internal structures of each organization. The benefits of scale and scope can be built both through internal development and cooperation based on the principles of strategic partnership, where the use of resources can be optimized by operating in coordinated markets. Here we are dealing with a relational paradigm in strategic management. The literature emphasizes that the more dynamic the industry and the possibilities of influencing demand, the stronger should be the orientation on the exploration of inter-organizational relations[6].

It is also worth paying attention to the fact that having permanent partners (exploiting relations) enables carriers to use the experience gained during cooperation and deepens the trust and consolidation of common knowledge resources.

[5] J. Niemczyk, *Uniwersalne archetypy zarządzania strategicznego* [in:] *Wyzwania współczesnego zarządzania strategicznego*, eds. A. Sopińska, P. Wachowiak, OW SGH, Warsaw 2017.

[6] E. Stańczyk-Hugiet, *Eksplorować czy eksploatować relacje międzyorganizacyjne?* [in:] *Strategie, procesy i praktyki*, series: Scientific Works of the University of Economics in Wroclaw No. 420, Publisher of the University of Economics, Wroclaw 2016, p. 286–297.

However, building relationships with new partners (exploration of relationships) allows access to new experiences, gives new market opportunities and extends the structural boundaries of the existing network. In both cases, companies can accumulate the resources of relational capital, which contributes to their survival and development[7]. In literature, this is referred to as ambidexterity, or strategic ability to explore and exploit inter-organizational relations. Referring this concept to the theory of alliances and their effectiveness, it can be noticed that current actions do not bring unambiguous, positive results. Often the assumed benefits are not achieved, because the entities compete with each other for limited resources and markets, which causes a tendency to mutually supplant, especially when their environment is more and more uncertain and competitive, or operate in crisis conditions. This picture also applies to the aviation sector.

2. Development of joint ventures on the air transport services market

In the aviation market, after more than 20 years of strategic partnership development based on strategic concepts, we are observing the intensification of cooperation within joint ventures, usually consisting of two strong carriers, representatives of the European and American market and several smaller important partners from the point of view of network construction.

There is also a new phenomenon of cooperation of low-cost carriers with network lines – traditional, but in these considerations we will not discuss it. The evidence of the power of joint ventures on the aviation market is the results of research conducted on the EU-US connection market, which shows that three groups of operators cooperating on the basis of joint ventures on this market have about 80% share, including Air Canada-Austrian Airlines – Brussels Airlines-Lufthansa-SWISS and United Airlines over 28%, Air France-Alitalia-KLM-Delta around 26.5%, and the American Airlines-British Airways-Elysair-Finnair-Iberia joint venture around 24%[8].

The airlines cooperating in the first of these joint ventures already served in the transatlantic market in 2013, almost 14.5 million passengers, in the second over 13.6 million passengers and the third over 12.2 million passengers. The main success of these three groups resulted from the construction of a transatlantic network of connections in the hubs, most of which belonged to the 30 largest airports in the world, which indicates the importance of incorporating strong hub ports in the network offered, in which joint ventures partners have their bases. The multiplicity of markets served as part of joint venture and of course

[7] C. Cummings, *Structure-based Alliance ambidexterity: an empirical study of the American Motion Picture Industry*, Journal of Business and Management 2014, 19(3), p. 23.

[8] I-100 International Segment (All Carriers) US Department of Transportation, Bureau of Transportation Statistics, http://www.transtats.bts.gov/Fields_asp?Table_ID=261 (access: 20.02.2018).

the presence of the largest players from the aviation market in each of these agreements is of great importance[9].

Among the 10 ports in which the largest number of passengers in regular traffic in EU-US relations were served in 2013, the transport leaders were carriers with bases in them and members of one of the three joint venture agreements operating on these routes. It seems that this is due to the fact that global multilateral alliances as such lost the value of strategic agreements, while capital relationships and joint venture agreements can be qualified as the main factors tightening the multifaceted multilateral cooperation that appears inside the constellation. As a rule, carriers – members of the alliance who do not have capital ties or are not parties to joint venture agreements are considered by other members of the alliance as competitors, as confirmed by D. Boniecki's research[10].

Joint venture agreements improve the competitiveness of operators that are parties to these agreements. Mutual abolition of property restrictions by the European Union and the United States can significantly improve the scope and depth of this cooperation and its economic effects in the future. Of course, certain conditions for joint action must be met, structure of cooperation with each partner, quantification of synergy effects and selection of a way to share the benefits gained from cooperation. Report prepared by L.E.K. Consulting indicates problems that should be covered by the scope of the contract and considered jointly both before its conclusion and during joint venture cooperation, as conditions in the near and distant surroundings of joint venture partners often change and certain elements of the contract should be adjusted. As it appears from the report by L.E.K. Since the establishment of a groundbreaking partnership between Northwest Airlines and KLM Royal Dutch Airlines, i.e. for more than twenty years, we have been observing a growing global cooperation between carriers on the aviation market. Historically, it took various forms. After a period of development of code-sharing agreements, joint loyalty programs and classic alliance agreements, giving a lot of freedom and independence to each partner, there was a period of tightening cooperation based on joint ventures. The authors of the abovementioned report by A. Lewis, Z. Momin, P. Smith and B. Catlin emphasize that in the new strategies of competing in the aviation market, a joint venture-based partnership can be a tool leading to new levels of development and maximization of common values of these agreements. Currently, on the market of air services, over twenty air carriers benefit from cooperation within the joint venture. It is estimated that in 2016, around 25% of all global long-distance traffic was realized by lines operating as joint ventures. It is worth noting that only 10 years ago, only about 5% of long distance traffic was served by airlines operating under the joint ventures.

Partners of joint venture agreements can have different scale of operation. On the one hand, they are such large aviation companies as, for example, Qantas, Emirates, Delta or Virgin Atlantic, while the other may be small regional carriers. We are dealing with joint ventures concluded with flagship carriers with high

[9] More on the subject, see: D. Boniecki, *Podaż usług na rynku przewozów lotniczych między UE i USA w kontekście polityki otwartego nieba*, PhD thesis, SGH Warsaw School of Economics, KZiF, Warsaw 2016.

[10] D. Boniecki, *Podaż usług…*, p. 222–229.

potential and small ones representing regional markets, which allows these great operators to access the so-called emerging markets that are just developing on different continents. In turn, this allows achieving economies of scale, reach or compaction by a global partner in such agreements, while smaller lines gain access to global networks. An example of such a symbiotic relationship may be a long-term partnership built by the Dutch KLM carrier from Kenya Airlines or Delta with the Brazilian carrier GOL. The degree of integration of websites within joint ventures is growing, often referred to as "virtual mergers". They are becoming more and more popular not only on the transatlantic market, but all over the world. It is anticipated that by 2021, more than 35% of all global long-haul air traffic will be served by joint venture lines. Especially, this cooperation will intensify between mature aviation markets (the EU, the USA) and developing markets such as Latin America and Africa. More than half of the traffic associated with the US market will be supported by operators cooperating within the joint ventures within the next five years.

A similar trend is observed in the relations between Europe and the USA with the Asian market. Especially Chinese airlines are seen as a strong partner in the development of cooperation based on joint venture agreements. This is mainly due to the dynamic growth of air traffic in China and the economic and demographic potential of this country. Chinese airports as hubs of airlines from this region is an important element of joint venture network construction based on hub and spoke systems.

An example of this type of cooperation is the joint venture agreement concluded in 2017 between Air China and Lufthansa, described as a breakthrough in the global aviation market. Other major American carriers following the Lufthansa route include capital agreements, such as the recently announced capital investments of Delta Air Lines in China Eastern and American Airlines in China Southern. Such actions can be considered as a step towards further tightening cooperation and concluding agreements on joint ventures of these carriers on the air transport services market.

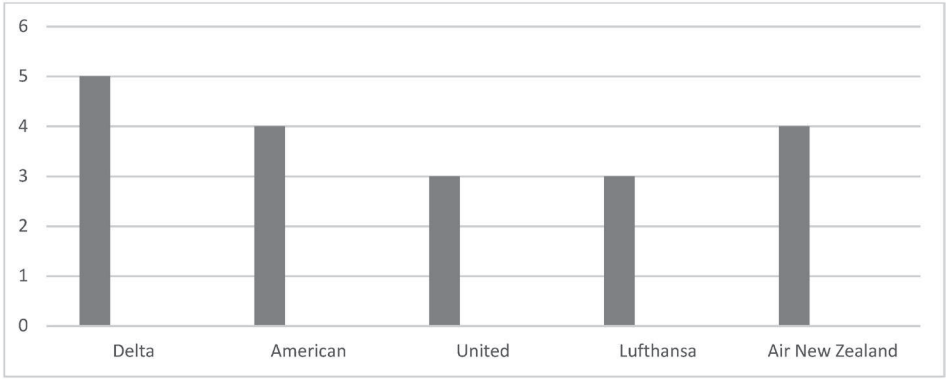

Figure 3. Number of established joint venture agreements by selected air carriers
Source: L.E.K. Consulting

Figure 3 shows the scale of engagement of major airlines in agreements based on agreements on joint ventures.

The scale of obtained effects depends not only on the scope of coordination of activities, but also on the way of organizing and managing a joint venture. The most important element of this partnership is to build the basis of mutual trust. The sustainability of joint venture agreements depends primarily on the partners' ability to construct clear, fair and flexible partnership rules. The essence of joint venture agreements is the simultaneous tightening of cooperation between the parties and the exclusion of competition between them. The mechanism of sharing costs and revenues means that for each of the partners it remains irrelevant which of them performs the cruise[11]. The joint venture agreements in aviation are referred to as "metal-neutral", i.e. independent of the airplane (metal) belonging to a given carrier. Operating on these conditions is always subject to the consent of the authorities supervising the protection of the market and competition. And so, the European Commission studied joint venture agreements between airlines based in the EU countries, and carriers from the United States concluded in 2009–2016. Depending on the provisions of such contracts, revenue or profit are divided regardless of who makes the connection.

It is also important to define the scope and proper structure of joint ventures, which is usually the starting point of negotiations. The key issues considered in these negotiations are:

– establishing the regions and routes covered by the joint venture partnership contract;
– defining the home markets and external partners of the agreement;
– exclusion from the common network of non-relevant routes or market segments for joint ventures (e.g. typical tourist transports operated by one of the partners).

Here you can give an example of the joint venture agreement between Singapore Airlines and Lufthansa, where different markets are included in the agreement, namely the entire traditional market of the Lufthansa group, namely Germany, Austria, Belgium and Switzerland, while the area in the Singapore Airlines domain is widened and includes Australia, Indonesia and Malaysia. On the other hand, the Delta Airlines and Virgin Atlantic contracts excluded a significant portion of the tourist traffic carried out by Virgin in the Caribbean.

As a result of the tests, further problems identified during the JV conclusion were identified, among others:

– how to solve the issue of exclusive service of routes;
– can other parties partners be included on joint routes;
– whether third parties can operate certain markets on an exclusive basis;
– how to manage a joint venture;
– what the joint venture organizational structure should look like.

In the joint venture agreement between Air France and Delta, assumptions regarding service and exclusions from the traffic of individual partners were made, sharing markets with India. And so Delta operates to Mumbai, and KLM to New Dehli. In the A ++ joint venture agreement, Air Canada, Lufthansa and United fully

[11] *Ibidem*, p. 74.

cover the North America, Europe, Africa, India and Middle East markets together. An important issue at the stage of establishing the joint venture is also the decision whether joint venture applies to all air transport, i.e. cargo and passenger, or only one of these market segments, and whether revenues or profits will be shared.

Another problem are pricing strategies, tariff structure binding under joint venture, integration of tariff systems. In many cases, there are simplification of joint venture tariff systems, their standardization and transparency for customers. Such solutions were adopted by the ANA and Lufthansa lines establishing tariff zones in Europe and Japan. This allowed the ANA carrier to significantly expand ticket sales to 190 destinations in Europe. Before the joint venture agreement, ANA offered its services to 120 ports.

However, the most important problem, including many aspects affecting the success of any joint venture project in the aviation sector, is the partnership mechanism, that is the mechanism for sharing revenues or profits. For this purpose, such issues should be settled[12]:

– way of calculating revenues or profits;
– whether the joint venture will be based on revenue or profit sharing;
– for what period to conduct a joint calculation of revenues and profits;
– how to settle and account for differences in the level of profitability of joint venture partners;
– how to shape the effectiveness of each partner when the results are worse than the base ones;
– how to share costs when the cooperation mechanism is based on profit;
– how to introduce and use the proportionality clause in practice, so as to rationalize transport capacity offered on common routes;
– how to protect yourself and respond to random or crisis situations that violate the established cooperation mechanism;
– what is the optimal period for which the contract is concluded;
– how to settle disputes and other problems undefined in the contract;
– how to deal with and terminate the joint venture agreement and how to terminate your cooperation.

The most important thing is to establish a mechanism for sharing revenues or profits in operating joint ventures. Currently, the situation regarding the use of these mechanisms is presented in Table 1.

Table 1. The mechanism for sharing benefits in joint ventures

Year of establishment	Partners	Mechanism for sharing benefits
2009	A++ (Air Canada, Lufthansa, United)	Income
2009	Delta, Air France, KLM, Alitalia	Profit
2010	American, IAG, Finnair	Income
2011	ANA, United	Income
2011	JAL, American	Income
2011	Delta, Virgin Australia	Income

[12] L.E.K. Consulting.

Year of establishment	Partners	Mechanism for sharing benefits
2011	Air New Zealand, Virgin Australia	Income
2012	ANA, Lufthansa, Austrian, Swiss	Income
2013	Qantas, Emirates	Income
2013	Japan Airlines, IAG, Finnair	Income
2013	Delta, VirginAtlantic	Profit
2014	Air New Zealand, Singapore	Income
2014	Air France, KLM, Kenya Airways	Profit
2016	Singapore, Lufthansa	Income
2017	Delta, Aeromexico	Profit
negotiated	LATAM, American	Income
negotiated	LATAM, IAG	Income
negotiated	Air New Zealand, United	Income
negotiated	Air China, Lufthansa	Income
negotiated	Delta, Korean Air	Profit
negotiated	American, Qantas	Income

Source: L.E.K. Consulting

Based on the data presented in Table 1, it can be concluded that the vast majority of joint ventures are based on the revenue sharing mechanism.

In every issue we meet with very different provisions in joint venture agreements between airlines. It is important that they are accepted and respected by the parties to the agreement.

Conclusions

Regardless of the scope and provisions of detailed joint venture agreements between airlines, they always take into account the aspirations to create such cooperation mechanisms that allow to maximize jointly achieved effects. They also always take into account the differentiation of added value brought to joint venture by each party.

The analysis of the development of joint ventures clearly indicates that such agreements tighten cooperation between aviation market operators and allow for obtaining much wider synergic values than marketing agreements under strategic alliances. It can even be said that we are dealing with a kind of erosion and devaluation of alliances. Referring to the Polish aviation market, it seems that the national carrier of Polish Airlines LOT should not only be privatized as soon as possible, but also make efforts to build its future based on joint venture agreements, especially on long-haul routes in the transatlantic and Asian markets.

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THE ROLE AND RESPONSIBILITY OF STAKEHOLDERS IN THE PLANNING PROCESS OF THE SUSTAINABLE URBAN MOBILITY IN THE CITY KRAKOW

Abstract

This article presents the process of identifying and selecting stakeholders, whose role and position is important to achieve the overall goals of planning sustainable urban mobility in the Municipality of Krakow. The authors identified possible conflicts and coalitions between stakeholders and illustrated how this could affect the development of the planning process in the context of the geographical area, integration between strategic planning documents, availability of resources and general validity.

Keywords: transport planning, mobility, SUMP

Introduction

Transport planning is often a controversial area where decisions are widely commented and require, in the light of political democratization, social acceptance. Involvement of stakeholders and citizens may legitimize decisions and, in addition, lead to new, innovative management models that try to balance different positions and interests. Participation in planning processes reflects the general integration of citizens and groups in decision-making processes, and thus participation in authority.

The term commonly used, in the context of participation is a "stakeholder", who may be a natural person, group or organization that is affected by the proposed project or which may have an impact on the project and its implementation[1]. These

[1] A. Fung, *Participation, Deliberation, and Representation in the Policy Process. Civic Engagement in the 21st Century*, University of Southern California, October 1–2, 2004.

groups generally cover public opinion as well as a wide range of other groups (e.g. enterprises, public authorities and interest groups). In transport planning, different groups of stakeholders may be subject to considerable influence. The rigorous limitation of their routine transport behaviour[2] will affect their daily operations.

1. Identification of stakeholders

In order to find appropriate ways to deal with dominant or weak stakeholders and those dealing with intermediate positions, according to the guidelines of the handbook[3] three main groups of stakeholders were distinguished depending on the specific position they occupy in the decision-making process:

– basic stakeholders: Who will ultimately be affected (positively or negatively) by new transport activities (for example: on residents within various social or professional groups, individual city districts, business sectors, individual entities)?
– strategic stakeholders: Who is the political responsibility (presidents, mayors, councilors, other levels of government)? Who has financial resources (public and private funds)? Who exercises power (in a given sphere or territory)? Who has the skills and knowledge (public administration, universities, private sector) in the field of transport and related fields (land use, environmental protection, education, health, tourism, etc.)?
– intermediaries: Who implements the transport policy (operators of public transport and infrastructure, public administration, police, etc.)? Who implements the main transport activities (suppliers of goods, ports, airports, etc.)? Who represents important interest groups (associations, chambers of commerce, cooperatives, networks)? Who carries out information activities and reports on transport (authorities, operators, local media)?

In a more specific approach to the GUIDEMAPS[4] project handbook, seven main groups can be classified:

– local government authorities – actions will be initiated by local or regional authorities due to the competences and availability of human and financial resources;
– residents – as the final recipients of the results of the conducted policy of managing mobility, in individual groups of people using public transport, drivers, cyclists and pedestrians;
– enterprises operating on the local market – due to the possibility of increasing their development potential related to better accessibility for customers and better operating conditions on the market;

[2] K. Hebel, M. Wolek, *Perception of modes of public transport compared to travel behaviour of urban inhabitants in light of marketing research*, Scientific Journals. Transport/Silesian University of Technology 2016, 92.
[3] *Ibidem*.
[4] GUIDEMAPS – Gaining Understanding of Improved Decision Making and Participation Strategies, European (5th RTD Framework Programme).

– local transport operators – effective implementation of Plan for Sustainable Urban Mobility will increase the attractiveness of public transport as the main subsystem contributing to the balancing of the entire transport system;
– carriers of goods, delivery and logistics companies;
– non-governmental organizations – in particular those working for sustainable transport, associations of cyclists, pro-ecological foundations, organizations working for people with reduced mobility, for pedestrians, etc.;
– other entities (e.g. cultural institutions, sports and recreation centers, providing educational services, schools, colleges, business incubators, etc.).

After identifying the stakeholders, their mutual relations were analyzed. The analysis was based on the list of four criteria concerning: interest in the process of planning sustainable urban mobility and the level of influence on the decisions made in this process. The aim of a systematic analysis of relations between stakeholders is to get a clear picture of conflicts of interest or potential coalitions and to identify a group of stakeholders who can show different levels of participation, opportunities and interest in a given issue.

The process of mapping stakeholders in the influence-interest matrix, which aims to group stakeholders based on the level of impact and/or significance, is presented in Table 1 and 2.

Table 1. Matrix INFLUENCE vs. INTEREST

	Low level of influence	High level of influence
Little interest	A group of stakeholders with the lowest impact	Useful for formulating opinions and decisions
Big interest	An important group of stakeholders, may require increased rights	The most critical group of stakeholders

Source: GUIDELINES – Developing and Implementing a Sustainable Urban Mobility Plan – Rupprecht Consult – Forschung und Beratung GmbH, Eltis 2014

Table 2. List of all potential stakeholders in the matrix INFLUENCE vs. INTEREST matrix for the city of Krakow

	Low level of influence	High level of influence
Little interest	City Secretary	Miejskie Przedsiębiorstwo Komunikacyjne S.A. w Krakowie
	Treasurer of the City	Mobilis sp z o.o.
	Research institutes	Local media
	The operator of the city bike system – Wavelo	Main employers
	Car-sharing operator – Traficar	People with limited mobility
	Primary and secondary schools	Parents and children
	Urban media	Elderly people
	Provincial Inspector for Environmental Protection	Bus operators

Table 2. cont.

	Low level of influence	High level of influence
Little interest	Domestic non-governmental organizations	Krakow Balice Airport
	PKP Przewozy Regionalne	Residents of neighboring communes
	Kraków Nowa Huta Przyszłości S.A.	Polish State Railways
	Police Headquarters in Krakow	Universities – public and private
	Municipal Police of Krakow	Authorities of neighboring communes, commune of the Krakow poviat
	Polish Motor Union	Local companies
Big interest	Miejska Infrastruktura sp. z.o.o.	The Mayor of the City of Krakow and the Deputy, Plenipotentiaries and Advisors of PMK
	Foundations and associations	Residents of Krakow
	Tourists – domestic and foreign	City Hall of Krakow
	Krakowski Park Technologiczny sp. z o.o.	The Management of Municipal Infrastructure and Transport in Krakow
	Project managers at UMK as part of the Project Management System	City Council of Krakow
	Research and development centers of companies	Krakowski Holding Komunalny
	Technology Transfer Centers	Trasa Łagiewnicka S.A.
	Local business incubators	City Development Agency
	Association of Engineers and Technicians of Communication of the Republic of Poland	Boards and District Councils I–XVIII
	Marshal's Office of the Lesser Poland Voivodship	Municipal Investment Management
	Lesser Poland Voivodship Office	–
	Ministry of Infrastructure	–
	Ministry of Development	–

Source: own elaboration

In Table 2, the stakeholders are grouped due to their potential level of influence on the planning process and the degree of interest in participating in this process. The key are the stakeholders representing a high level of influence and a lot of interest. They should have the greatest potential to influence the shape of the Sustainable Urban Mobility Plan, and in many cases they will provide the acceptable infrastructural and organizational solutions acceptable in the document.

2. Strategic stakeholders

The process of adopting and then implementing the Sustainable Urban Mobility Plan requires broad acceptance at the political level, which in Krakow is tantamount to the resolution of the controlling body and constituting the Municipality of Krakow – the City Council of Krakow. The adoption and implementation of Sustainable Urban Mobility Plan requires taking action to influence the councilors in order to obtain the approval of the majority of the forty-three members of the City Council of Krakow.

Actions taken towards local governments should rely on the use of strategies and operational techniques based, among others, on marketing, based on rational, facts supported arguments presented by adopted action plan.

According to W. Ofman[5], the effectiveness of the actions taken does not only depend on positive relations with decision-makers, but depends on the ability to choose the right strategy for communicating arguments. As there is no closed catalog of techniques and tools to influence representatives of municipal government, new instruments are constantly emerging, which were characterized in Table 3, developed on the basis of a publication dedicated to issues of public relations in the opinion-forming process[6].

Direct actions consisting in a traditional form at bilateral meetings are the most effective form of influence on decision-makers. In turn, indirect actions focus on shaping public opinion in order to obtain its support in the first place[7]. Indirect activities will require the City Hall to engage in its so-called third party, which may be media or NGOs and associations supporting the idea of adopting the Sustainable Urban Mobility Plan.

Table 3. Catalog of activities of influencing the representatives of the municipal government

Direct actions		Indirect actions
Personal	Written	
– meetings – discussions – press conferences – parties – public speeches – prsentations – visits – discussions in committees – networking	– letters – e-mails – studies – statistical data – articles – booklets – books – posts in social media	– third parties (environmental authorities, acquaintances, friends) – public actors (leaders of social organizations) – mobilizing public opinion (petitions, demonstrations, interviews in the media) – science and experts (sponsorship, conferences, job publications)

Source: own elaboration

It will be of great importance to refer to current social campaigns in the area of environmental and health protection that allow to emphasize the group context of the issue and to obtain an atmosphere conducive to the adoption of a resolution regarding the Sustainable Urban Mobility Plan.

The effectiveness of actions taken against politicians requires tact, diplomacy and sensitivity to social engineering aspects. For ethical reasons, you should not use blackmail or exchange benefits, however, each time a decision on how to approach a particular group of local government officials should be preceded by a cost-benefit analysis.

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[5] N. Ofmański, *Public affairs and lobbying* [in:] *Sztuka public relations. Z doświadczeń polskich praktyków*, ed. B. Janiszewska, Związek Firm Public Relations, Warsaw 2011, p. 281.

[6] S. Kuśmierski, *Public relations w procesie opiniotwórczym*, WSE, Warsaw 2006, p. 47

[7] M. Molęda-Zdziech, *Od lobbingu klasycznego ku cyberlobbingowi. Grupy interesu i lobbing. Polskie doświadczenia w unijnym kontekście*, IFiS PAN, Warsaw 2011, p. 179–180.

Taking into account the above-mentioned conditions concerning methods of exerting influence on local government representatives in the context of the city of Krakow, direct meetings of representatives of the city authorities with Councilors are recommended in order to present arguments for the admission of the Sustainable Urban Mobility Plan. In discussions, emphasis should be placed on the effects of the adoption of the Sustainable Urban Mobility Plan, such as the improvement of air quality and the reduction of road congestion, which have recently become very important.

3. The division of roles and the scope of responsibility of stakeholders

In the table, divided into 4 different groups (in terms of direct impact on the planning process), the main stakeholders of the process were compiled, bearing in mind their role in shaping sustainable mobility policy – from initiators/decision makers, through observers to final recipients of services resulting from decisions taken.

Table 4. List of potential stakeholders in the context of the division of roles and responsibilities

No.	Entity/Group	The role and scope of the stakeholder's responsibility
Authority/Board		
1	The Mayor of the City of Krakow and the Deputy, Plenipotentiaries and Advisors of PMK	Main initiators of the Sustainable Urban Mobility Plan process, political responsibility
2	City Secretary	Coordination of arrangements with selected entities
3	Treasurer of the City	Financial plan of the Sustainable Urban Mobility Plan, budget of individual activities
4	Krakow City Hall – selected departments	Department – responsible for the development and consultation of the Sustainable Urban Mobility Plan as a whole, other departments – substantive input, arrangements, etc.
5	City Council of Krakow	The main political body accepting the document at the political level through the resolution of City Council
6	Boards and District Councils I–XVIII	Participants of the arrangements at the local/district level
7	Authorities of neighboring communes, commune of the Krakow poviat	Participants of the arrangements at the level of the functional area of Krakow
8	The Management of Municipal Infrastructure and Transport in Krakow	Implementer of majority of the implementation activities assumed in Sustainable Urban Mobility Plan
9	Municipal Investment Management	Implementer of majority of the implementation activities assumed in Sustainable Urban Mobility Plan
10	Miejska Infrastruktura sp. z.o.o.	Implementer of some of the implementation activities assumed in Sustainable Urban Mobility Plan

No.	Entity/Group	The role and scope of the stakeholder's responsibility
11	Trasa Łagiewnicka S.A.	Implementer of some of the implementation activities assumed in Sustainable Urban Mobility Plan
12	Krakowski Holding Komunalny	Participant of arrangements at the local level
13	City Development Agency	Participant of arrangements at the local level
14	Police Headquarters in Krakow	Participant of arrangements at the local level, responsible in the selected area for monitoring the effects of Sustainable Urban Mobility Plan implementation
15	Municipal Police of Krakow	Participant of arrangements at the local level, responsible in the selected area for monitoring the effects of Sustainable Urban Mobility Plan implementation
16	Project managers at UMK as part of the Project Management Syst	Participants of arrangements at the local level (e.g. organizational and IT issues)
17	Marshal's Office of the Lesser Poland Voivodship	Participant of arrangements at the regional level
18	Lesser Poland Voivodship Office	Participant of arrangements at the regional level
19	Ministry of Transport and Construction	The participant of the arrangements at the national level provides the framework and guidelines for the plans at the regional/urban level
20	Ministry of Development	The participant of the arrangements at the national level provides the framework and guidelines for the plans at the regional/urban level
Companies/Operators		
1	Miejskie Przedsiębiorstwo Komunikacyjne S.A. w Krakowie	Participant of arrangements at the local level
2	Mobilis sp z o.o.	Participant of arrangements at the local level
3	Bus operators	Participant of arrangements at the local level
4	Krakow Balice Airport	Participant of arrangements at the local level
5	Car-sharing Operator – Traficar	The role of the observer and provider of selected services
6	The operator of the city bike system – Wavelo	The role of the observer and provider of selected services
7	Main employers	The role of the observer and provider of selected services
8	Local companies	The role of the observer and provider of selected services
9	Polish State Railways	Participant of arrangements at the local level
10	PKP Przewozy Regionalne	Participant of arrangements at the local level
Local communities		
1	Residents of Krakow	Participants of arrangements at the local level, key recipients of Sustainable Urban Mobility Plan products
2	Local media	The role of the observer and provider of selected services
3	Municipal media	The role of the observer and provider of selected services
4	Polish Motor Union	The role of the observer and provider of selected services
5	Tourists – domestic and foreign	Key recipients of the Sustainable Urban Mobility Plan products
6	Residents of neighboring communes	Key recipients of the Sustainable Urban Mobility Plan products
7	Parent and children	Key recipients of the Sustainable Urban Mobility Plan products
8	Elderly people	Key recipients of the Sustainable Urban Mobility Plan products

Table 4. cont.

No.	Entity/Group	The role and scope of the stakeholder's responsibility
9	People with limited mobility	Key recipients of the Sustainable Urban Mobility Plan products
	Other	
1	Universities – public and private	The role of the observer and provider of selected services
2	Research institutes	The role of the observer and provider of selected services
3	Provincial Inspector for Environmental Protection	Participant of arrangements at the local level
4	Primary and secondary schools	The role of the observer and provider of selected services
5	Association of Engineers and Technicians of Communication of the Republic of Poland	Participant of arrangements at the local level
6	Foundations	Participant of arrangements at the local level
7	Foundations and associations	Participant of arrangements at the local level
8	Krakowski Park Technologiczny sp. z o.o.	The role of the observer and provider of selected services
9	Kraków Nowa Huta Przyszłości S.A.	The role of the observer and provider of selected services
10	Research and development centers of companies	The role of the observer and provider of selected services
11	Technology Transfer Centers	The role of the observer and provider of selected services
12	Local business incubators	The role of the observer and provider of selected services
13	Domestic non-governmental organizations	The role of the observer

Source: own elaboration

Conclusions

Examples of transport planning in Europe, where controversial urban development projects have led to mass protests show that planning processes without public legitimacy can be blocked and, in the worst case, even abandoned. Such cases also show that the rejection of intentions by society initiated a broad discussion about planning. The idea of sustainable urban mobility should encourage local governments, institutions and organizations to go beyond their own borders and responsibilities in order to ensure consistency and complementarity with strategies in related sectors (transport, spatial planning and land use, health, energy, municipal services, education, security of public order and safety, etc.). Such coordination is a major challenge for planning sustainable urban mobility, but it is also the main source for implementing innovation and improvement of planning processes.

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FREIGHT TRAM CONCEPT FOR THE CITY OF POZNAŃ

Abstract

The work presents the concept of a freight tram and examples of trams used in European cities. The concept of a freight tram in Poznań and the Municipal Integrated Logistics Center that manages the delivery of goods to customers has been presented. The use of a freight tram in urban logistics requires from the city carrier a detailed plan for the delivery of cargo from shippers to recipients, in order to eliminate congestion in the tram network. The establishment of the Integrated Logistics Center gives you the opportunity to create a coherent system of goods distribution and transport traffic control in the city. Some selected patterns of transshipment of goods using, among others, railway terminals are presented.

Keywords: freight tram, city logistics

Introduction

Most of contemporary cities are struggling with problems arising from their development, aging infrastructure, population migration and many other factors. Currently, about 50% of the world's population lives in cities, while according to statistical data by 2030, this share will increase to 60% and up to 2050 to 70%. With such tendencies one should take into account the growing problems related to the overpopulation of urbanized areas. Another transport problem of cities is the increasingly difficult optimization of both passenger and freight flows in cities.

The increase in the demand for goods in the city results in the increase of the number of vehicles, which means increased congestion, pollution of the urban environment, increase in distribution costs, extension of delivery time, etc. In connection with the increasing problems of urban transport, the introduction of freight

trams seems to be a good solution because it can offload the roads, reduce exhaust emission and improve many other factors that affect the quality of life in cities[1].

The city plays an important role in the life of its inhabitants. It provides places of residence, employment and contributes to the growth of economic and cultural activity. However, permanent access to goods and services can be considered the most important function of the city. This requires the creation of a harmonious and efficient transport system. The constantly growing number of inhabitants and, consequently, the growth of mass consumerism causes a rapid development of the city's shopping and service zones. One of the possibilities to solve this problem in cities which have a tram network is to use it for the transport of goods[2].

1. The idea of a freight tram in the city

The use of trams to supply goods to stores located in the city centers allows to eliminate many inconveniences related to transport with the use of trucks. Cities that have a tram network become potential candidates for the introduction of a freight tram. The idea of moving cargoes in the city area using trams is also conducive to a change of views on tram transport, systematically developing since the 1980s. Environmental aspects also play an important role here, a smaller number of cars improve air quality and reduce noise in the city.

The strengths of a freight tram in the city include:
- low noise level – thanks to the electric drive used;
- environmental performance – the tram does not generate virtually any pollution;
- spatial range – track infrastructure allows the entry of a freight tram into the strict center, where road transport has restrictions (parking);
- reduction in the number of vans in favor of freight trams.

The weaknesses of tramway freight are:
- dependency on the tram infrastructure;
- possibility of delays with the schedule;
- high costs of specialized rolling stock;
- blocking lines -during delays of loading and unloading operations.

An indispensable part of plans to introduce rail freight transport in the city is technical conditions. Therefore, it is necessary to analyze all possibilities, limitations and get acquainted with available means that will help in the integration of various modes of transport in order to ensure a smooth flow of goods[3].

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[1] J. Poliński, *Rola tramwaju towarowego w ograniczeniu wykorzystywania TIR-ów zaopatrujących duże miasta*, Problems of Rail Transport 2008, 146, p. 53–64.

[2] I. Dembińska-Cyran, *Zastosowanie tramwajów towarowych w obsłudze dostaw na obszarze miasta*, LogForum Electronic Journal Science Logistyka 2005, 6.

[3] K. Lewandowski, *Użycie tramwaju towarowego w logistyce miejskiej*, Logistyka 2002, 6, p. 63–66.

2. Freight trams in Europe

The beginnings of the use of trams for transporting cargo date back to the turn of the 19th and 20th centuries. The first attempts were made in the times when wagons pulled by horses left the tracks. However, the small animal train capacity significantly reduced both the speed of transport and the maximum load capacity. The solution to transport problems has become the use of electric trams.

At the beginning of the 20th century, there were mainly two types of tram carriages in Europe. The first one were electric vehicles, covered by self-propelled vehicles, mainly rebuilt from passenger trams (removal from the interior of seats). The second group consisted of trailer wagons. Most often, these were remodeled coalmines and platforms.

In Poland, freight tram transport services functioned in almost every city with a more extensive network of railways. In 1917, the transport of postal items was launched in Poznań. Szczecin started the operation of post trams two years later than Poznań, in 1919. The last example of a city with trams was Wrocław. The system was launched in 1921[4].

The increase in the importance of freight trams took place with the outbreak of World War II due to the rationing of fuel and requisitioning trucks and passenger cars for the purposes of military operations. In the German-occupied city, trams were used to transport ammunition or to export slave-labor products from the Jewish population.

After World War II, freight trams were used to debris Polish cities. Figure 1 shows a tram set (tram and railway carriages) for the removal of debris from damaged Wrocław.

Nowadays, trams are used to a small extent for transporting cargo. They are mainly used in municipal transport companies as trams for transporting mechanical parts between depots. However, there is hope that the goods will be relocated to the rails thanks to several western cities implementing modern tramway projects.

Figure 1. Removal of debris from Wroclaw after the war
Source: http://wroclaw.hydral.com.pl/64189,foto.html (access: 2.04.2010)

Dresden is currently one of the few cities in the world where trams are used to transport goods. The idea of introducing a freight tram to the streets of the city gave rise to the late '90s of the twentieth century with the idea of building a VW "transparent car factory" by VW. The factory called "Glass Manufactory" was to be

[4] M. Zych, K. Lewandowski, *Tramwaje towarowe na świecie i w Polsce*, Logistyka 2015, 4, p. 3828–3835.

available for passers-by, that is, that they could observe the VW car construction process from the street. The production plant was built at Straβburger Platz. This location is not accidental. Investors wanted the factory to be located near the city center[5].

It was decided to build the main part warehouse, being at the same time the logistic center of the new factory, to build outside the city center of Dresden and arrange delivery of parts of the cars to the factory with special trams. Trunk sidings were built at the factory and logistics center. They were connected to the municipal tram network. The production plant also gained a terminal enabling loading and unloading of containers with parts from the tram, as shown in Figure 2.

Figure 2. Unloading terminal at the VW factory in Dresden
Source: http://www.begim.com/ext/funvideos/interestinglinks/VolksWagen/Cargo_Tram.jpg (access: 3.03.2018)

The city of Zürich, following the example of Dresden, decided to use trams to transport freight. This idea is not a new thing in the city. Between 1898 and 1966, various goods were transported by trams. From 1898, urban rail transport was used to move mail. The Cargotram project was developed jointly by the Department of Municipal Transport VBZ and the Waste Disposal and Recycling Facility. Special points have been designated in the city where residents can bring waste. Along with the growing transport demand, the Cargotram offer was extended in 2006 with the E-tram, i.e. the tram collecting the so-called Electro. Figure 3 shows a goods trolley for collecting and transporting waste[6].

Amsterdam is the next city after Dresden and Zurich, where it was planned to launch a freight tram. The idea of introducing this fairly innovative form of urban transport of goods was initiated in 2004. The tram infrastructure of Amsterdam was used to distribute the goods. Special distribution centers called Cross Docks have been designed. Figure 4 shows the built-in city tram in Amsterdam. Despite numerous awards received by the City Cargo project, a lot of support and interest, successful tests and bold plans for the future, it has not been realized[7].

[5] http://www.begim.com/ext/funvideos/interestinglinks/VolksWagen/Cargo_ Tram.jpg (access: 3.03.2018).
[6] http://upload.wikimedia.org/wikipedia/commons/2/27/Cargo_Tram_outside _Zurich_ Hauptbahnhof.JPG (access: 3.03.2018).
[7] http://tram-2.andreetjes-website.nl/cargo_tram_amsterdam/citycargo_801_1_akp.jpg (access: 3.03.2018).

Figure 3. A freight tram in Zürich in the colors of the VBZ carrier
Source: http://upload.wikimedia.org/wikipedia/commons/2/27/Cargo_Tram_outside _Zurich_Hauptbahnhof.JPG (access: 4.03.2018)

Figure 4. A freight tram in Amsterdam City Cargo VBZ
Source: http://tram-2.andreetjes-website.nl/cargo_tram_amsterdam/citycargo_801_l_akp.jpg (access: 4.03.2018)

The Güterbim project in Vienna is the latest solution for the use of trams to transport loads in the city. The basis for starting the work was the resolution of the Vienna City Council taken in August 2004. It concerned the introduction of freight transport throughout the urban rail infrastructure. The Güterbim concept was part of the F & E I2 "Intelligent Infrastructure" program of the Ministry of Communications, Innovation and Technology. The plans for launching a freight tram were jointly developed by Urban Transport Company (Wiener Linien), Vienna Local Railways (Wiener Lokalbahnen), TINA Vienna-Transport Strategies GmbH and Vienna Consult Verkehrsberatungsgesellschaft mbH. Figure 5 shows a freight tram in Vienna made for the Güterbi project[8].

[8] http://www.mp-video.at/Video/VIDEOS/Guebi.jpg (access: 4.03.2018).

Figure 5. A freight tram used in the Güterbi project
Source: http://www.mp-video.at/Video/VIDEOS/Guebi.jpg (access: 4.03.2018)

The launch of the freight tram in Dresden in 2001 and the numerous economic and environmental benefits resulting from this fact for the city contributed to the increase of interest in this ecological form of transport. Many cities use this form of freight transport, which is probably the only alternative to crowded cities.

3. The concept of a freight tram in Poznań

Poznań is one of the fifteen cities in Poland with an extensive tram network. Periodically enlarged since its inception, it covers all five districts of the city: Grunwald, Wilda, Jeżyce, Stare Miasto and Nowe Miasto. Four depots and one square of holding tracks are located within the system. The total length of individual tracks is about 157.7 km, of which nearly 140 km are track lanes. Tram routes are terminated with 14 loops. The largest grouping of tracks is located in the city center. Almost ¾ of the entire network consists of traffic rails separated from traffic, allowing trams to efficiently travel during rush hours. There are over 20 daily tram lines in Poznań. The manager of the rail transport infrastructure is Urban transport company.

The delivery system in the city could be based on the use of a logistics center acting as an operational base from where freight trams would deliver cargo directly to recipients or selected points on the tram network, and could then be transported, for example, by electric cars. An important element of the whole system would be the Urban Integrated Logistics Center (MZCL), whose main goal would be to manage tramway transport in Poznań.

The proposed location is the area in the vicinity of the newly created tram depot between the production plants of the Lech beer company and the M1 shopping center (Figure 6). The location of the Urban Integrated Logistics Center in this area is not accidental. The space on Franów is mainly used by production plants and supermarket chains, which would allow for quick acquisition of suppliers and potential recipients of goods. This depot would provide a stopping place for freight trams as well as adequate facilities and technical support[9].

[9] P. Kuczyński, *Tramwajowy transport towarów w aglomeracji miejskiej Poznania*, Diploma thesis, Poznań 2010.

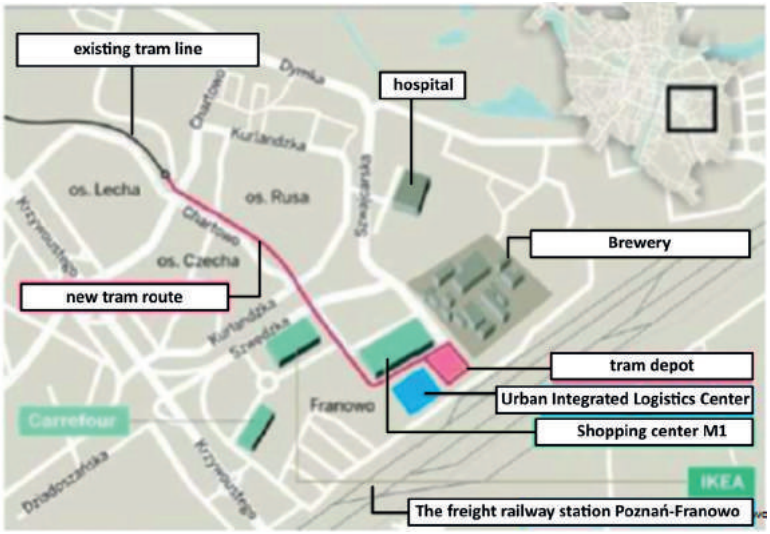

Figure 6. Location of the Municipal Integrated Logistics Center in Franowo
Source: P. Kuczyński, *Tramwajowy transport towarów w aglomeracji miejskiej Poznania*, Diploma thesis, Poznań 2010

A very important argument in favor of the location of the center on Franowo is the railway lines running through this area and very important for the national road transport. There is a large freight station in the area where trains with cargo throughout the country are formed daily from around 3500 wagons.

Important advantages of Poznań are the numerous points located in its area, which could be adapted in the project of a freight tram. Of course, this involves a lot of financial effort to adapt such locations to design expectations. These places include:

– tram loops;
– so-called "dead tracks" – places where there are tram tracks not used for years or used sporadically;
– potentially strategic places for the development of the concept of a freight tram.

The following is an example of the use of tram loops as potential terminals for transshipment of goods.

Górczyn – a tram loop in the south-western part of Poznań in the immediate vicinity of the Poznań – Górczyn station and a line leading to Berlin and Western Europe (Figure 7). The distance between tram and railway tracks is only about 70 meters. This place is suitable for organizing a terminal for reloading goods from railway wagons to a tram. For this purpose, the so-called closed "Staroberlinski Trails" located east of the Górczyński viaduct. Bringing the tram track to the "Staroberlinski Tracks" and building a transshipment point there would create new prospects for many institutions nearby.

Figure 7. The proposed connection of the tramway loop on Górczyn with railway tracks
Source: P. Kuczyński, *Tramwajowy transport towarów w aglomeracji miejskiej Poznania,* Diploma thesis, Poznań 2010

Dębiec – location: the southern part of Poznań. There is a tram loop there, it borders with railway tracks, as shown in Figure 8. The disadvantage of this place is a small area of the Dębbie loop itself, therefore, due to the limited space, an important solution would be to "plug in" one tram track to the railway line near Poznań – Dębiec. Such an undertaking would allow not only to launch freight transport, but also to connect the rail passenger traffic with the urban traffic.

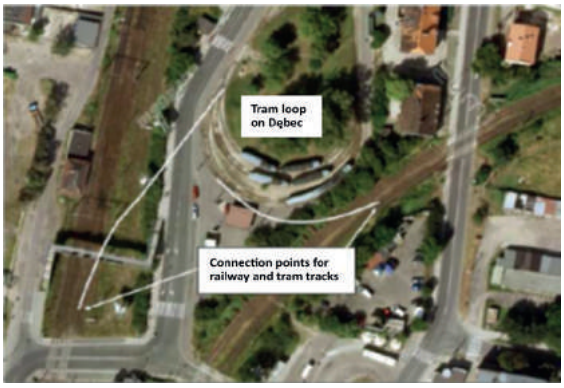

Figure 8. Possible variants of connecting the tram terminal in Dębec with the railway node
Source: P. Kuczyński, *Tramwajowy transport towarów w aglomeracji miejskiej Poznania*, Diploma thesis, Poznań 2010

Starołęka – south-eastern part of the city. The tram terminal is located next to the depot on Forteczna street, which has a direct connection to the railway tracks (Figure 9). The connecting track has been unused for several years. It could be used as a place where two-system freight trams would enter the railway tracks. Next to the depot at the Poznań – Starołęka railway station there is a closed ramp and railway sidings. With a small financial outlay, this place could be adapted to reload goods from railway wagons to freight trams.

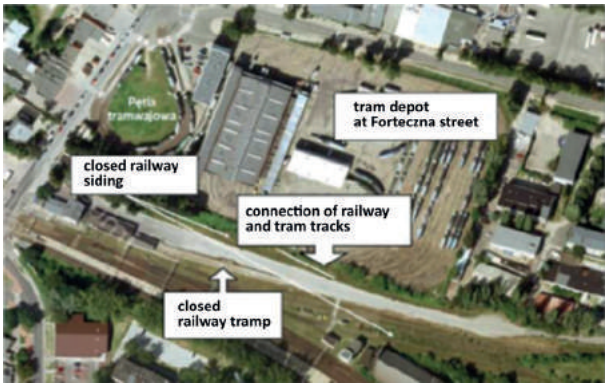

Figure 9. Tram depot at Forteczna street and unused railway sidings
Source: P. Kuczyński, *Tramwajowy transport towarów w aglomeracji miejskiej Poznania*, Diploma thesis, Poznań 2010

Conclusions

The paper presents issues related to the transport of freight inside urban agglomerations with the indication of freight trams, as an alternative logistic solution to the supply problems of cities, related to the constantly growing number of cars affecting the creation of the congestion problem.

The development of the idea of transporting goods by trams can be a solution to the supply problems of many cities. High payload (replacing sometimes four semi-trailers) and spatial coverage make the freight tram a vehicle that can contribute to a significant reduction in the number of vans and trucks, thereby reducing the risks associated with improper parking and blocking streets and reducing congestion. Due to the type of drive (electric motors), the tram does not emit any fumes and generates much less noise than internal combustion engines, which makes it an environmentally friendly vehicle.

The introduction of freight trams in the city is an extremely complicated task. There are many legal and technical issues to be solved when creating a project. Efficient operation of this type of transport requires a lot of involvement of both authorities and entrepreneurs.

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CHANGES IN ACCESSIBILITY IN EASTERN EUROPE DUE TO THE ROAD INVESTMENTS ALONG THE VIA CARPATIA CORRIDOR

Abstract

The main objective of the article is to assess the potential impact of the completed Via Carpatia route on changes in the accessibility of regions on a European scale. The model of potential accessibility in the international approach was used (sources and destinations at the NUTS3 level). The accessibility analysis showed that the range of impact of the investment is extensive and extends from the north of the continent to central Turkey, and the effectiveness of construction of individual sections is strongly dependent on the simultaneous investment in neighboring countries.

Keywords: Via Carpatia corridor, road investments, TEN-T road network, potential accessibility

Introduction

The aim of the functioning and development of the TEN-T network is to ensure territorial cohesion of the EU, improve the free transport of people and freight, and consequently – improve the functioning of the single internal market, stimulate economic growth, and improve the competitiveness of Member States and the entire EU on a global scale. Creation of a coherent and interoperable, multimodal transport network with unified, high technical parameters is possible only in the case of full coverage by the entire European Union network. This also applies to areas located near the eastern border of the EU. During the previous (2007–2013) and current

(2014–2020) financial perspective, these areas have significantly improved their accessibility as a result of the implementation of latitudinal investments linking them with the core areas of individual countries as well as the entire Union. However, at the same time there is still a lack of a southern communication axis that could favor the development of peripheral areas, and at the same time play an integration role towards the Western Balkans, Eastern Partnership countries as well as Turkey and the Middle East. An initiative that can fill this gap is the postulated way of Via Carpatia (along with branches).

It is assumed that changes in accessibility will be one of the main effects of investment activities in the Via Carpatia corridor. The corridor runs through peripheral areas, which have been characterized by a relatively lower level of accessibility (both on the EU scale and within the Member States). This means that the development effect of this improvement can be significant, including for undertaking investment activities by potential investors, which should be encouraged by modern road infrastructure. The correct quantification of the expected effects of Via Carpatia at the European level is extremely important. They allow for an objective assessment of the legitimacy and then the preparation of future investment projects, including their proper stages.

The article presents a forecast concerning changes in the transport accessibility of regions through which the basic route of Via Carpatia will run, in the European system, taking into account changes resulting from the implementation of investments on particular sections of the route.

The main goal of the article is to assess the potential impact of the completed Via Carpatia route on changes in the region's accessibility. The spatial scope of the study (both sources and destinations) covered the entire geographical Europe (including the countries of the former Soviet Union, including the European part of Russia), as well as Turkey. Such a large territorial range distinguishes the analysis from many previous European accessibility studies[1]. The applied approach allows also to assess the effects of investments on both sides of the external EU border, and thus to identify the reducing impact of this border, understood as a formalized spatial barrier[2]. The time horizon of the survey goes back 10 years from the planned completion of the Polish part of the investment (i.e. 2025–2035). Thus, the analysis, including the forecasts of changes in accessibility, are made in the long-term perspective, i.e. until 2035. It is a perspective in which the creation of the whole rout can be considered real.

The accessibility analysis was carried out first for the whole of Europe to indicate what the overall level of accessibility of the regions along the Via Carpatia route is. Then, the accessibility changes for the entire Via Carpatia route were simulated. The authors analyzed the expected shortening of travel time between the complete 1585 transport regions in Europe, as a result of bringing the Via Carpatia route

[1] *Transport services and networks: territorial trends and basic supply of infrastructure for territorial cohesion. Final Report*, ESPON 1.2.1, 2014; K. Spiekermann et al., *TRACC Transport Accessibility at Regional/Local Scale and Patterns in Europe. Final Report*, ESPON Applied Research 2014.

[2] Z. Rykiel, *Koncepcje granic w badaniach geograficznych*, Geographic Journal 1990, 62, p. 263–273 and T. Komornicki, *Granice Polski. Analiza zmian przenikalności w latach 1990–1996*, Geopolitical Studies 1999, 5, p. 348.

to a level equivalent to that expected for the TEN-T network corridor, which means at least a level equal to the expressway (in places where a change of category is planned on the highway). So-called net effect of improving accessibility as a result of implementation of Via Carpatii was examined, i.e. assuming ceteris paribus – other unchanged factors. The article is the result of theoretical research carried out under the own grant financed by The National Science Centre (Poland) No. UMO-2014/13/B/HS4/03397.

1. Via Carpatia route

The initiative to build a road called Via Carpatia was undertaken for the first time at an international conference organized in Łańcut in 2006. Its initiators were Poland, Lithuania, Slovakia and Hungary. The transport ministers of these countries then signed a declaration of joint efforts to enter the trail into the TEN-T network. In 2010, it was supported by other countries (Bulgaria, Romania and Greece).

The planned main route of Via Carpatia, according to the so-called The Łańcut Declaration (2016) runs from Klaipeda and Kaunas in Lithuania through Białystok, Lublin and Rzeszów in Poland, Slovak Prešov and Košice to Miskolc and Debrecen in Hungary and further to Romania, where the main route Via Carpatia runs from Oradea, through Arad and Timisoara in the direction of Bulgaria (Sofia) and Greek ports (Thessaloniki, Alexandropolis) and then further to Turkey, to Istanbul (Figure 1). The Via Carpatia "arms" lead from the Polish Baltic ports to south-eastern Poland, joining with subsequent ones leading to Ukraine Lublin with Kowel and Lublin and Rzeszów with Lviv. In Ukraine, the arms run from the western part of the country towards Kiev and further to the port of Odessa. In Ternopil, the route also branches towards Romanian Galati and Bucharest. In addition, in Romania, the route branches off in Oradea and Lugoj towards the port of Constanta. In Bulgaria, the route leads from Sofia to the border with Turkey, and then to Istanbul.

It is worth noting that the Polish Ministry of Infrastructure has taken the initiative to include the Via Carpatia corridor into the TEN-T core network along the entire course of the next TEN-T network update. According to art. 54 By Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on EU guidelines for the development of the trans-European transport network, the European Commission should review the implementation and possible updating of the core network by 31 December 2023.

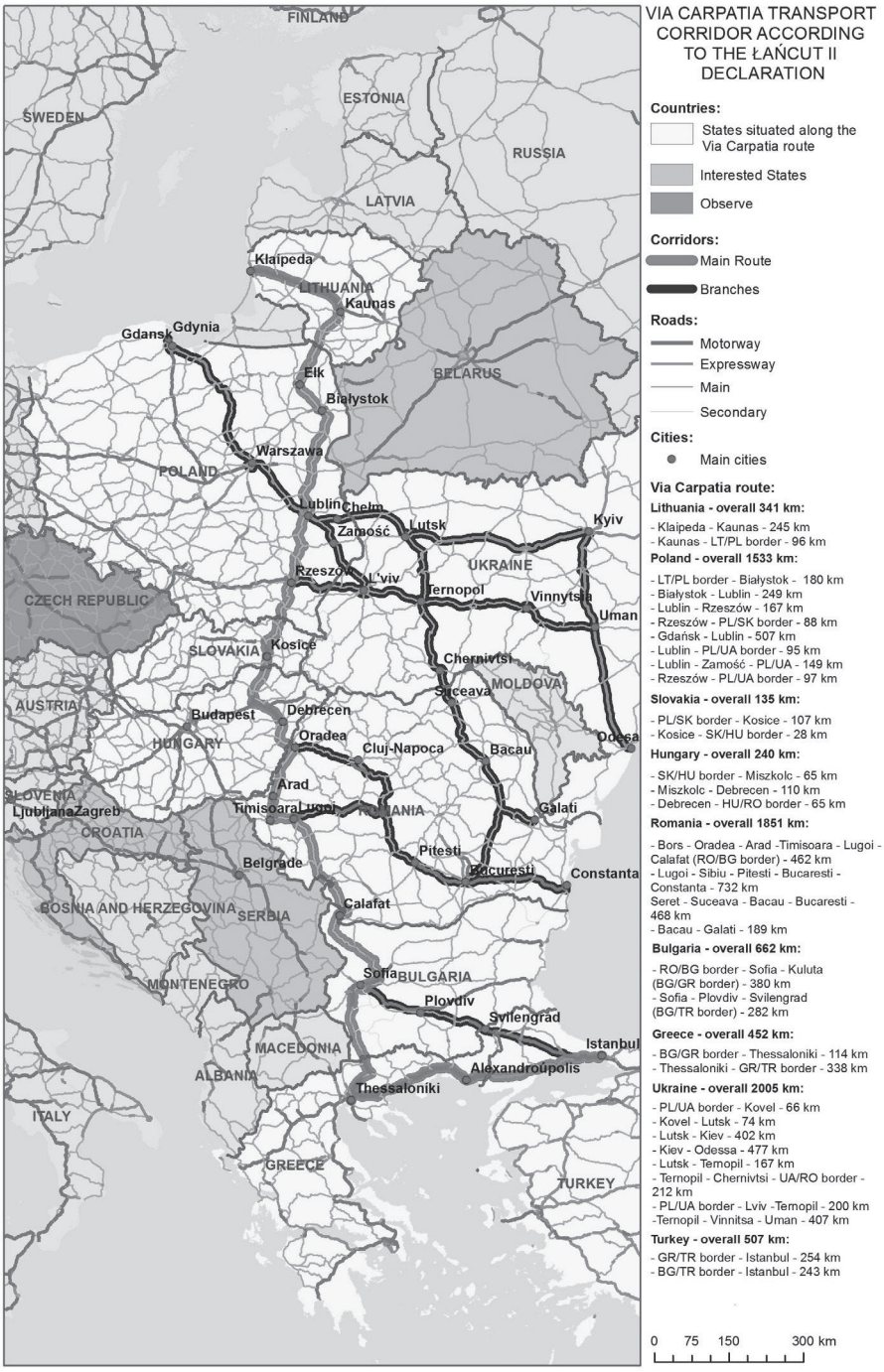

Figure 1. Via Carpatia – route diagram
Source: own elaboration based on materials from the Ministry of Infrastructure

Connections of Via Carpatia corridor with other road corridors within core network TEN-T are as follows (the names of the towns/cities are indicative only, actual courses vary in relation to the location of the town/city, relevant junctions are provided in the description of the network status in individual countries):

1) North Sea – Baltic TEN-T corridor. Klaipeda–Elk;
2) Outside TEN-T, Ełk–Knyszyn;
3) Comprehensive network TEN-T, Knyszyn–Lublin;
4) Core network TEN-T, Lublin-Rzeszow;
5) Comprehensive network TEN-T, Rzeszow–Prešov;
6) Rhine–Danube TEN-T corridor, Prešov–Košice;
7) Comprehensive network TEN-T, Košice–Miskolc;
8) Mediterranean TEN-T corridor, Miskolc–Debrecen;
9) Comprehensive network TEN-T, Debrecen–Arad;
10) Rhine–Danube TEN-T corridor and Orient-East Med TEN-T corridor, Arad–Drobeta–Turnu Severin;
11) Outside TEN-T, Drobeta–Turnu Severin–Calafat/Vidin;
12) Orient-East Med TEN-T corridor, Calafat–Vidin–Thessaloniki;
13) Core network TEN-T, Thessaloniki–Ipsala;
14) Outside TEN-T, Ipsala–Istanbul.

The overall state of the Via Carpatia corridor can be briefly described as follows. Currently, i.e. at the end of 2017, the Via Carpatia is only partially ready; indicatively, the following sections are in existence:

– Lithuania, Klaipeda–Kaunas;
– Poland, short sections in the area of Suwałki, Lublin and Rzeszów;
– Slovakia, almost the whole section Prešov–Košice–border with Hungary;
– Hungary, Miskolc–Debrecen;
– Romania, Arad–Lugoj;
– Bulgaria, Botevgrad–Sofia–Blagoevgrad;
– Greece, almost the whole course;
– Turkey, built in the dual carriageway standard, although not meeting the requirements for expressways on the western section. No further actions needed, except for road renovations.

Realistically, it is very likely that by 2023 sections that are at least at the stage of tender at the end of 2017 will have been delivered the following sections:

– Lithuania, almost the whole Lithuanian section to the border with Poland;
– Poland, aections Suwalki–Elk and Lublin–Rzeszow;
– Slovakia, completion of the missing sections between Prešov and the border with Hungary;
– Hungary, completion of the missing sections on all the course of the route;
– Romania; no significant activities, except for the short section on the border with Hungary;
– Bulgaria, no significant activities, except for the short missing section between Sofia and the border with Greece;
– Greece, completion of the missing section.

2. Research methodology

Accessibility can be measured using a number of methods, from which the so-called potential accessibility was chosen[3]. This method allows simulation of changes in accessibility in spatial terms as a result of putting any part for use (e.g. a new part of an expressway or raising the road category on a given section), or a group of sections or the entire program, e.g. CEF. The most important distinction of potential accessibility is that the attractiveness of the travel/carriage purpose increases with its size and decreases as the physical, temporal or economic distance increases (in the case of this study it is travel time). As an attraction (destination) the population in the transport region from 2015 was taken into account. A model built for the whole of the European continent at the NUTS3 level (area of the European Union) was used. Outside the European Union, the rest of European countries were divided according to the administrative division (for example, Ukraine, Belarus and Russia are divided into so-called oblasts, and in NUTS units in Turkey and some other countries based on Eurostat data). In total, 1585 transport regions were distinguished. Thus, it is the first European accessibility model functioning in Poland.

The road network for the whole continent has been developed by adapting the Open Street foundation for the model, dividing the network into five categories of roads: motorways, expressways, dual carriageways, single-station national roads, other roads of regional and local importance. The code speeds applicable in a given country were adopted, while reducing the speed for regional and local roads. The waiting times at borders were also taken into account. All the capitals of the regions (relatively largest cities in the transport regions connected with the network, when the capital of the region was much smaller than the largest city) were connected. The OGAM application developed at the Institute of Geography and Spatial Organization of the Polish Academy of Sciences was used to simulate potential accessibility. The model always performs simulation on all the shortest travel routes between any pair of transport regions.

Formula was used for so-called potential accessibility. In the described study, the formula takes the form:

$$A_i = M_i f(t_{ii}) + \sum_j M_j f(t_{ij}) + \sum_k M_k f(t_{ik}) + \sum_l M_l f(t_{il}),$$

where:
$M_i f(t_{ii})$ – the own potential of the NUTS3 region and (t_{ii}) inter-regional journey time[4].

The sum of own potential and the second component $\Sigma_j M_j f(t_{ij})$ is the domestic potential where (t_{ij}) is the travel time between any pair of NUTS3 regions and j within a given country. The sum of the domestic potential and the third component $\Sigma_k M_k f(t_{ik})$ is the international potential of the Schengen area where (t_{ik})

[3] P. Rosik, *Dostępność lądowa przestrzeni Polski w wymiarze europejskim*, Geographic Journal 2012, 231, p. 310.

[4] D.C. Rich, *Population potential, potential transportation cost and industrial location*, Area, 1978, p. 222–226; J. Gutiérrez, *Location, economic potential and daily accessibility: analysis of the accessibility impact of the high-speed line Madrid–Barcelona–French border*, Journal of Transport Geography2001, 9, p. 229–242.

is the travel time between two transport regions NUTS3 and k located in different countries belonging to the Schengen area. Ultimately, the sum of the potential of the Schengen area and the fourth component $\Sigma_l M_l f(t_{il})$ is an international potential on a European scale where (t_{il}) is travel time taking into account waiting time at borders, Schengen area and other borders on the European continent.

In the case of The resistance of the space, describing the speed of decline in the attractiveness of the destination along with the longer travel time, used the exponential function (exponent) which is related to the appropriate selection of the parameter β in the function of space resistance f (cij) = exp (–βt). The appropriate parameter β is indicated in the function of space resistance, the selected indicator β = 0.005775, for which the attractiveness of the destination is half at two hours of travel, and 10% at about 400 minutes (6 hours and 40 minutes)[5].

3. The analysis of changes in accessibility as a result of implementation of the entire Via Carpatia route

The results of the study indicate that the continental distribution of accessibility is to a large extent "based" on the European core (Figure 2). The Ruhr region has the highest level of this indicator. Along with moving away from the European core, access is falling in all directions, but the rate of this decline depends to a large extent on the density of population and the condition of road infrastructure. In Poland, for example, access is falling from the south-west towards the north-east, but it remains at a higher level (more than 40 units) along the A2 (to Warsaw) and A4 (to Kraków and Tarnów) highways. The enclaves of higher accessibility in the peripheral areas of Eastern Europe are primarily Moscow and Istanbul, and to a lesser extent St. Petersburg.

The area along the Via Carpatia route is characterized by a rather low level of accessibility on the European scale, from very low values in Lithuania and northern Greece, to relatively higher ones in the vicinity of Istanbul and in the central part of the corridor (from Lublin to Timisoara), again with the "peak" in Rzeszów (Figure 3).The better accessibility of the Polish, Slovak and Hungarian sections depends on the geographical location of the EU core area and better developed latitudinal infrastructure. The Via Carpatia is in this case an important role connecting the areas between the East-West highways (Polish A4, Slovak D1, Hungarian M3) to these routes. The improvement of the accessibility indicator can therefore take place as a result of the cumulative effect of Via Carpatia and latitudinal highways, proving that the meridional system cannot be seen as an alternative to the latitudinal one. They are completing in improving the accessibility of the eastern borderland of the European Union. In this context, it is advisable that Via Carpatia be supplemented with routes perpendicular to it, such as the eastern section of the Polish A2 highway.

[5] M. Stępniak, P. Rosik, *Accessibility improvement, territorial cohesion and spillovers: a multidimensional evaluation of two motorway sections in Poland*, Journal of Transport Geography 2013, 31, p. 154–163.

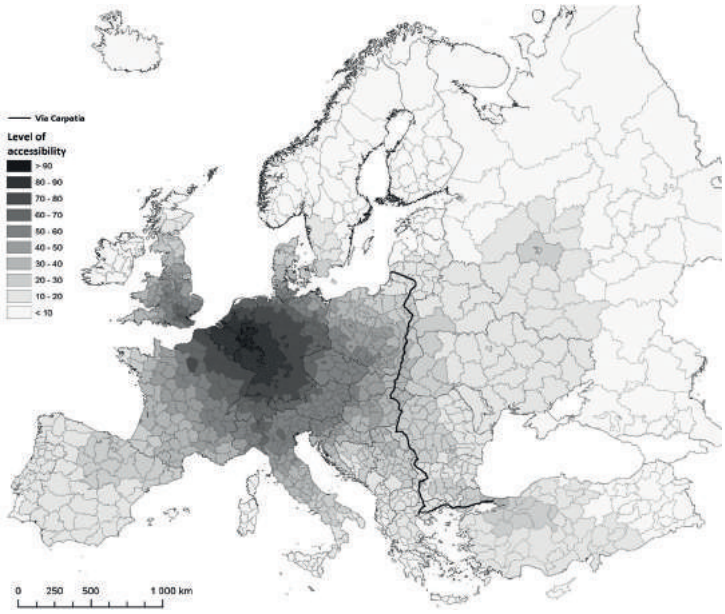

Figure 2. Road accessibility in 2013
Source: own elaboration using the potential model and speed model of IGiPZ PAN

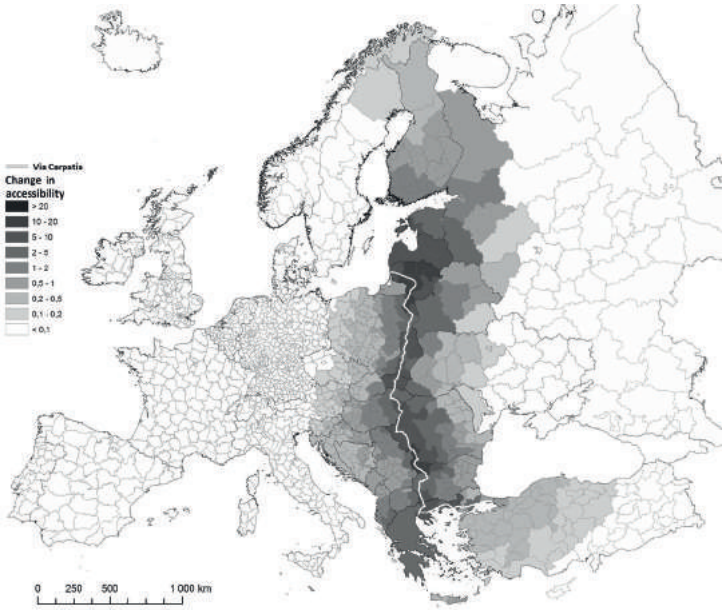

Figure 3. Change of road accessibility to the population as a result of implementation of the Via Carpatia investment
Source: own elaboration using the potential model and speed model of IGiPZ PAN

The accessilibity analysis showed that the range of impact of the investment is extensive and extends from the north of the continent (northern Finland, and even Sweden and Norway) to central Turkey. On the western side, the improvement of accessibility above 0.1% is visible more or less east of the Polish-German border to Slovenia. The largest beneficiaries of the investment are, like in the short journeys, the Bulgarian-Romanian and Polish-Lithuanian borders (improvement in Kaunas by 14.3%), but the large effects of improving accessibility (over 5%) are also visible in Latvia, Greece and in principle in all the countries along the corridor have regions where accessibility increases above 5%. The smallest effects are for obvious reasons along those sections that already at the end of 2015 had the status of an expressway or highway, and no further investments are planned there (Miskolc, Sofia, Istanbul, Thessaloniki).

It is worth noticing that there is the significant improvement of accessibility in some countries outside the European Union. This applies to what is interesting, to a greater extent Belarus and northern Russia (the area of St. Petersburg) rather than Ukraine. Physical remoteness means that the new investment improves accessibility in northern Russia and in Finland. In the case of Ukraine, which is closer to the core of the European Union, the effect is not so large as to offset the losses resulting from the infrequently penetrating border. The beneficiaries of the route in a natural way are also Western Balkans, in particular Serbia (in Vojvodina, a growth of 5%) and Macedonia. However, the benefits of the order of 0.5–1% go back to the Adriatic coast (in Albania). Generally, the countries located west of Via Carpatia (through which the route does not run) benefit all the countries of the former Yugoslavia, Albania, as well as Austria and the Czech Republic. The analysis of potential accessibility provides arguments for increasing the number of countries involved for Serbia, and second for Macedonia and Albania.

Expectations of individual countries and regions in relation to Via Carpatia can be naturally different. In the peripheral areas (north and south end of the corridor, but also its branches to the east – Ukraine), they are associated with better communication with Central Europe and indirectly Western Europe. In the central part of the corridor the justification of building the corridor one should look for in acceleration of economic development through better use of additional endogenous potentials (less dependent on connections with the western part of the Union).

Conclusions

Accessibility should be understood as the existence (creation) of an opportunity for social and economic development in the regional and local dimensions. It is a measure of the extent to which the transport network fulfills the condition necessary for development. From this point of view, the eastern peripheries of the European Union remain, in a large part, an area with development opportunities reduced by the underdevelopment of transport infrastructure, expressed by lower spatial accessibility indicators. The analysis confirmed that the construction of the Via Carpatia route can improve this situation. However, the possible positive investment result is selective in the territorial sense. It is also dependent on other

investments, including routes with latitudinal and oblique runs. It is not an alternative to them, only a complementary one. As a rokad route connecting peripheral areas, it is a "second-line" investment in respect of routes linking the periphery to core (national and European) areas. Most of these trails have already been established or are being implemented (especially in Poland in Slovakia and Hungary). In this context, taking the initiative to build the Via Carpatia road is now justified.

The above-mentioned selectivity of the obtained effects is clearly visible at the level of individual cities along the Via Carpatia route. The improvement of accessibility is of particular importance for medium-sized cities located in the northern and central part of the route (e.g. Lublin, Rzeszów, Kowno, Košice). They are characterized by a relatively weak own potential and good initial accessibility (geographic proximity of the core of the European Union and the existence of new latitudinal road routes). The new route may be an additional development impulse for them, resulting not only from the connection on the north-south axis, but also from better communication with their own facilities. Earlier research results on the impact of transport infrastructure improvement on development indicate that it concentrates rather in metropolitan centers and large cities and remains problematic in the periphery and rural areas[6]. On the other hand, in already large metropolises already formed (in the analyzed case they are Istanbul and to some extent also Sofia), the effect of the new road investment, measured by the improvement of the potential accessibility, is moderate. This leads to the conclusion that the main beneficiaries of the route may be those medium-sized cities, which are potential growth poles of the eastern periphery of the EU. The conducted study indirectly also showed the importance of cross-border cooperation in coordinating road investments. The efficiency of the construction of individual sections is strongly dependent on the simultaneous investment in both neighboring countries (e.g. on the Polish-Slovakian border).

It is important to conclude that the Via Carpatia route is potentially beneficial not only for the members of the European Union, but also for the so-called neighborhood of the Union. It reaches Istanbul – the largest city of Turkey and its arms are located in Ukraine. The countries concerned are (apart from Turkey and Ukraine) – Serbia and Bosnia and Herzegovina, as well as an EU member – Croatia. In the immediate vicinity of the route there are Macedonia and Belarus. Moldova is also located between the arms of the route in Romania and Ukraine. In the described system, Via Carpatia is an opportunity for the development of many regions located in the East of the European Union, not only as a single route, but also as the axis of the transport system serving the eastern borderland of the entire EU. Via Carpatia will also have a significant contribution to integrating EU and neighboring countries, especially Ukraine and Turkey. The trail contains the earlier concepts of transport corridors (such as the idea of Via Intermare). Long-term Via Carpatia will be conducive to the intensification of trade and investment links in the north-south direction, as a complement to the latitudinal system dominating in the EU.

The study clearly revealed the negative impact of a highly formalized border (the eastern border of the EU and the Schengen area) on the improvement of accessibility

[6] A. Cieślik, B. Rokicki, *Rola sieci transportowej w rozwoju polskich regionów: zastosowanie modelu potencjału ekonomicznego*, Acta Universitatis Niciolai Copernici. Economics 2013, 44(1), p. 113–127.

caused by transport investments. This is particularly visible on the Polish-Ukrainian and Slovak-Ukrainian borders. The construction of new routes (including Via Carpatia) thus creates a hidden development potential that could be activated with the liberalization of border regimes. This confirms earlier theses regarding the mutual impact of the infrastructural barrier and the formal and legal barrier as the basic elements limiting the penetration of borders[7].

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[7] T. Komornicki, *Granice Polski. Analiza zmian przenikalności w latach 1990–1996*, Geopolitical Studies 1999, 5, p. 348; P. Rosik, *Dostępność lądowa przestrzeni Polski w wymiarze europejskim*, Prace Geograficzne 2012, 231, p. 310; T. Komornicki, *Spatial and social effects of infrastructural integration in the case of the Polish borders* [in:] *Linking networks: The formation of common standards and visions for infrastructure development*, eds. M. Schiefelbusch, H.P. Dienel, Dorchester Ashgate, 2014, p. 187–208.

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DETERMINANTS OF MANAGEMENT OF THE MODERN LANDSIDE AREAS

Abstract

Modern airports and neighboring areas are characterized by functional integration, conducive to the targeted space management. Airports, in addition to strictly aerial functions, participate in non-aeronautical business activities. Such business activity generates economic benefits for all participants of the market environment and in many airports they exceed revenues from basic activity. The determinants of the scale and directions of development of landside areas are external factors (location, spatial, geopolitical, formal and legal) and internal (market, economic, marketing, environmental, other) individualized for particular airports. The dynamic development of processes and their effects justify the purposefulness of the problem and its exemplification. For its presentation, the method of verifying source literature and accumulated research material was used.

K**eywords:** airports, landside areas, determinants of space management

Introduction

Air transport determines evolutionary spatial transformations, socio-economic activity, market relations and territorial competitiveness. The effects of branch expansion (direct, indirect, induced and catalytic) are a derivative of airport operations and are reflected in the development of comprehensive investment projects around civil airports. The active role of the branch is confirmed by statistics characterizing its impact on the macro- and microeconomic development of the economy.

The primary determinant of the modern management of landside areas are terrain reserves, in the second place – branch infrastructure. The airports (interchange, regional) are nodes of urbanized areas and their regions generating air mobility

of the population, economic cooperation, expansion and opening of markets as well as strengthening the territorial availability and functional connections of spatial structures. Airports are also elements of multimodal transport systems that increase the communication and investment values of their surroundings. They are an asset of the innovation of a specific place, institutional equipment that facilitates communication with the international environment. In the 21st century, hard (measurable) location factors are replaced by soft factors (difficult to measure). Enterprises are looking for such location advantages that will not only help them minimize production costs, but also enable them to achieve a high competitive position. They also trigger the functions of constituting commercial areas around the airport, consistency of their elements, integrating location choices and behavior of entities managing them[1]. This development has a spatial, functional, technical, market, economic and environmental dimension, and each of them has the attribute of effective management.

Relations and synergistic effects of management of entities located in the landside areas[2] correspond to the model views of territorial cohesion[3], including Camani's (tequila model)[4] and the model of the E. Medeiros's star[5]. In the first one it exposes quality, identity and territorial efficiency, in the second – social and economic cohesion, cooperation/management, environmental sustainability and polytheism of development.

Landside areas are the implication of the city-forming and region-forming impact of transport points on the shape of functional space development[6]. In addition, there are economic functions (industrial, transport, commercial, logistic, marketing, social and managerial and business dependencies that determine their effective use). The wide range of activities in the landside areas constitutes their importance for macro- and micro-environment. Thus they are interesting for the local government institutions, state-owned entities and entities related or unrelated with aviation activities interested in locating in these areas, followed by other determinants: environmental, spatial, legal, administrative, technical and technological, economic,

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1 A. Ruciński, *Planowanie i lokalizacja sieci regionalnych portów lotniczych*, ZN UG, Dissertations and Monographs 80, University of Gdańsk Publishers, Gdańsk 1986, p. 1–249, also: T. Markowski, *Opinia w sprawie Komunikatu Komisji UE pt. Zielona Księga w sprawie spójności terytorialnej – przekształcenie różnorodności terytorialnej w siłę* [in:] *Spójność terytorialna wyzwaniem polityki rozwoju Unii Europejskiej. Polski wkład w debatę*, eds. A. Baucz, M. Łotocka, P. Żuber, Warsaw, Ministry of Regional Development, p. 70–97.

2 M. Stangel, *Rozwój strefy okołolotniskowej a port lotniczy – efekt synergii*, Przegląd Komunikacyjny 2013, 7, p. 18–25; also: D. Rucińska, A. Ruciński, *Współzależności rozwoju portów lotniczych i struktur zagospodarowania przestrzeni z uwzględnieniem stref okołolotniskowych*, Prace Komisji Geografii Komunikacji 2017, 20(2), p. 57–68, DOI 10.4467/2543859XPKG.17.011.7393.

3 The concepts of territorial cohesion were reflected in models such as: tequilas, stars, presented in the INTERCO, TeMo and other projects.

4 R. Camagni, *Territorial Development Policies in the European Madel of Socie*ty [in:] *Territorial Cohesion and the European Model of Society*, ed. A. Faludi, Lincoln Institute of LAND Policy, Springer, Berlin 2008, p. 33–47.

5 E. Medeiros, *Territorial Cohesion: A Conceptual Analysis*, Lizbona: Institute of Geography and Spatial Planning (IGOT) Alameda da Universidade, htp://ww3.fl.ul.pt/pessoais/Eduardo Medeiros/docs/PUBPAP_EM_Territorial_Cohesion.pd (access: 20.03.2018), p. 19.

6 *Porty lotnicze wobec polityki otwartego nieba*, ed. A. Ruciński, FRUG, Gdańsk 2006, p. 86–110.

marketing, socio-cultural. The list of location factors is open, often individualized in relation to a specific case.

The research shows that the landside areas are a source of spectacular benefits and economic effects of all beneficiaries. They are also a powerful instrument of territorial marketing in the process of shaping the image and brand of airports, cities and regions, and strengthening their competitiveness on the global market.

The availability of transport is attributed to the particularly high rank in the development of the airspace. This economic and market category as well as the index of transport territory management determines the quality and functional usability of these areas. In development programs of airports and their markets, the development and commercial use of landside areas is a strong stimulus of their favorable transformations.

1. Theoretical basis for the development of spatial structures – a review of the literature and methodology

Space is an environmental, non-renewable, rare good. Space management is focused, among others, on its features (limitation, resistance, diversity, dynamics, fulfillment, continuity, structure), reasons for economic diversity, legal and regulatory conditions (spatial planning, land management, real estate management, etc.), location choices and transformations of settlement production structures, including transport and regional ones.

Spatial management is the subject of interdisciplinary interest, including spatial and development policy, law, social sciences, geography, statistics, construction engineering, mathematics etc. Pioneering studies in this field include analyzes of representatives of the classical school regarding land use as a productive good and sources of rent [A. Smith (1776), D. Ricardo (1875), K. Marx (1885), others]. The theory, models and methods of its use with regard to distance (location of production resources, demand, costs, interactions) were presented by: J.H. von Thuenen (1826, 1842, 1850), W. Launhardt (1882), A. Weber (1909), D. Ricardo (1875), E.W. Burgess (1925), H. Hoyt (1939), A. Marschall (1925), W. Christaller (1933), A. Loesch (1933, 1940), C. Harris, E.L. Ullman (1945), E.M. Hoover (1949), F. Perroux (1950) and others. Even the oldest, classic models are used in the design of contemporary spatial systems. Market analyzes and interactions with the environment were conducted by: W. Launhardt (1882), A. Weber, A. Marshall and I. Prodoehl (1925), W. Christaller, T. Palander (1935), A. Loesch, J. Tinbergen (1939), C. Ponsard (1992), W. Isard (1965) and others. The new economic geography is connected, among others, concepts of growth poles – F. Perroux (1950), Krugmann (Nobel Prize winner in economics – 2008), polarization – G. Myrdal (1957), A. Hirschmann (1957), L.H. Klaassen (1997), J.G. Williamson (2008), others. Today, issues of space development are developed in Poland, among others by J. Regulski, R. Domański, T. Markowski, Z. Zuziak, K. Gawlikowska-Hueckel, J. Zaucha and teams of town planners and architects.

The problems of landside areas development appeared in the English literature at the beginning of the 21st century. The concept of Airport City and Aerotropolis was announced in the USA, the country with the most developed market of air services in the world[7]. Publications of American authors dominated the knowledge market in this area, but in the last decade more and more often elaboration of the authors of the representatives of countries in which the idea of the development of Airport Cities and Aerotropolis is practical (China, Korea, Great Britain, Germany, the Netherlands).

In Poland, the problem of development of landside areas is new and less attention is paid to the literature. This results from the lack of practices, experiments and research, and until recently, the possibility of adapting foreign experiences. Available publications are M. Stangel (2014), P. Wróbel (2012), A. Ruciński (1968, 1971, 2008), E. Marciszewska (2010), employees of the University of Economics in Poznań. For some Polish airports, Airport Cities projects have been developed for their commercial application. This topic, however, gains on research attractiveness, as evidenced by contributing scientific studies and recommendations for the effective development of landside areas.

The general principles of spatial management, including the public one[8], concern: rational use of it, creating systems subject to protection, obeying the paradigms of sustainable development policy. They refer to various structures including urban, local, regional, national[9], they are difficult to adapt quickly. The urban centers of settlements are a mobilizing factor for the development of contemporary space. Their strong subjectivity results from the concentration of the population, active in the management processes. Common features of city models are defined in the Leipzig Charter for the Sustainable Development of European Cities, indicating on the principles of its programming and financing[10]. According to P. Soldatos (1987), contemporary urban systems are characterized by import and export of factors of production, investment, workforce, goods and services, presence of foreign companies, organizations and diplomatic missions, export of factors of production, direct transport connections by highway systems, high-speed railways, international airports, intensive communication on a national and international scale, developed sector focused on relations with entities of international brand, municipal public and private institutions.

The rules for spatial development in Poland are specified in the Act on spatial planning and development of March 27th, 2003[11], individual acts (administrative decisions, e.g. building conditions, location of investments including public

[7] J. Kasarda, G. Lindsay, *Aerotropolis: The Way We'll Live Next*, Penguin Books Limited, 2011.

[8] One of the factors shaping the contemporary public space are social needs, tendencies to build relations that take into account the rational development and use of these areas.

[9] P. Lorens, *Gospodarowanie przestrzenią a polityka równoważenia rozwoju*, Studia Regionalne i Lokalne 2005, 2, p. 30–31.

[10] THE LIPSKA CARD for the sustainable development of European cities adopted at the informal ministerial meeting on urban development and territorial cohesion in Leipzig, 24–25 May 2007; the document developed during the German presidency deals with the challenges, opportunities and historical, economic, social and ecological differences of European EU cities, ministers responsible for urban development agreed on common principles and policies for their development.

[11] Act of 27 March 2003 on spatial planning and development (Journal of Laws of 2015, item 199, as amended).

ones), local spatial development law and general acts, omitting the generally applicable source of law (e.g. study of conditions and directions of spatial development of voivodeships, concept of spatial development of the country). Spatial management has a territorial and urban dimension (shaping the structures of its development), economic (implementation of economic undertakings and their effects), social (creating conditions for shaping the quality of life of the population), environmental (protection of the natural environment and sustainable use of its values.) The implementation of conditions harmonizes the objectives and benefits of the targeted development of space, in this aspect the analysis of the issues related to the immediate surroundings of airports – landside areas.

2. Air transport as an economic issue

Air transport development is defined by numbers, confirming a higher growth rate in the last half-century compared to other industries. The prosperity stimulators are: population growth, systematic growth of the creative "middle class", i.e. people earning from 10 to 100 USD/day including adjustment of amounts to the purchasing power of individual currencies and innovation-oriented interest, expansion of air connections, strong influence of global trade and international tourism. The declining prices of air services are also a favorable factor (in 2017, 60% lower than in 1970).

The Aviation Benefits 2017 Report shows that there are over 1400 airlines in the world and 3900 airports. The network of the most important air connections consists of over 54000 destinations, where in 2016 about 3.8 billion passengers were served, carrying out transport work of 7.1 trillion FTKs. Approximately 30% of transports are operated by low-cost carriers (LCC). Over 53 million tons of goods were transported (205 billion FTKs) with a total value of over USD 6.5 trillion (e.g. twice the GDP of Germany), of which approximately 87% were consumer goods purchased from online stores. Every day, about 10 million passengers use air transport and carry cargo for 18 billion USD. The share of air transport in global GDP reached 2.7 trillion USD (about 3.5% of GDP in 2014). In each of the given characteristics there was an increase compared to the previous year, i.e. 2016. It is estimated that in 2034 the values will double, reaching an increase of 122% in the indicated period[12].

In addition, aviation is a strong labor market, generating approximately 10 million seats in airlines and airports, traffic control and over 53 million outside of aviation mainly in the tourism sector (branch catalytic effect). In the light of ICAO forecasts, in 2034 the aviation industry will employ over 99 million people.

Contemporary airports, from branch points and transfer hubs are transformed into multifunctional, technological and economic organizations, often functioning in a varied market environment. Intensity of air operations requires adaptation of innovative solutions to eliminate the negative effects of congestion. It is estimated that in 2030, in the 100 largest airports, it may affect up to 1200 million passengers

[12] ICAO: Aviation Benefits 2017 Report – The importance of aviation on supporting the global economy, https://etradeforall.org/aviation-benefits-2017-report-importance-aviation-supporting--global-economy/ (access: 3.04.2018).

(about 20% of demand for air services). As this phenomenon applies to the largest airports, which will support 85% of global demand in 2030, there is a need for targeted adaptation of the offered usable space, changes in modeling organizational and management structures, including non-aeronautical and non-operational activities diversifying portfolio of airports. It is estimated that this income is 39.8% and 4.9% respectively. It is also estimated that airport revenues related to property management account for around 40% in global terms and around 30% in European airports with a systematic upward trend. The average of 0.7 sq. m of retail space per 1000 passengers handled generates 3–4 times higher revenues per 1 square meter compared to local shopping centers outside airports. The presented values justify the purposefulness of the transformations of airports and their surroundings, they constitute an encouraging direction of changes in their supply offer[13] and investments in facilities increasing transport accessibility, commercial and residential attractiveness of landside areas[14].

Long-term development trends of the air transport market point to the constant growth dynamics in each business segment, the progression of innovation and the pace of implementations ahead of other sectors of the economy and the impact on investors and stakeholders in the industry[15].

In 2017, 4.1 million passengers were served at Polish airports, i.e. by 6 million more than in the previous year (+17.7%). 39% of the share was allocated to the Warsaw Chopin Airport and 61% to regional airports. According to the Civil Aviation Office's forecasts, in 2025 the demand for air services in Poland will increase to 65 million passengers and in 2035 94 million passengers[16] will be served at Polish airports. This means an improvement in the national aviation mobility index, although it is still quite low (0.9 trips per year/person) in comparison with other Western European countries. Air traffic forecasts in Poland lead to rational, pro-development investment decisions conditioning the sustainable operation of airports and neighboring space.

3. Model landside areas

The globalization, civilization and development processes of air transport open the possibility of targeted development of landside areas. Contemporary demographic and economic processes trigger strong investment pressure in modern, intelligent and sensitive buildings and their users to manage change, implement effective models of management and economic and financial systems.

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[13] *Ibidem*, p. 40.

[14] www.dtz.com (access: 5.04.2018).

[15] Air traffic forecasts and market development are developed by aviation organizations and institutions and aircraft fleet manufacturers (eg ICAO, IATA, ULC, Airbus – "Global Market Forecast – GMF" (World Market Forecast), Boeing – "Current Market Outlook – CMO" (Current market prospects), "Bombardier Commercial Aircraft Market Forecast", "Embraer Commercial Aviation Market Outlook", "ATR Regional Turboprop Market Outlook". Boeing forecasts have been published regularly since the late 1950s.

[16] www.ulc.gov.pl (access: 4.04.2018).

In a model perspective, the landside areas[17], integrated commercial units generating unique added values are:

- areas of commercial development in the immediate vicinity of airports with entities involved in activities coordinated or uncoordinated with air transport and providing benefits to airports from their non-aeronautical activities. Some accidental locations may be a problem for the orderly development of landside areas. The immediate proximity of airports encourages the location of commercial service activities (car parks, logistics infrastructure, hotels, restaurants, motorization, etc.);
- Airport City – an economically active urban space with multi-purpose commercial facilities as a development of the non-aeronautical functions of the terminal. They are made up of generally available shopping and service complexes, business and logistics parks, conference and congress, exhibition and trade fairs, hospitality and recreation facilities, entertainment, salons and galleries, sometimes integrated with the management system with the airport. In the legally owned part, airports can undertake non-aeronautical commercial activities, e.g. investment, development, management, service, etc.;
- Aerotropolis – extensive spatial structure with a centrally located Airport City, an urbanized area, even with a radius of about 30 km with increased capacity of communication routes enabling connections with areas with diverse functions (industrial, service, business, airport needs, passengers and cargo, research and development, housing)[18];
- Airport Corridor with concentration of development of landside areas along transport routes in relations between airports and city centers with a strong public transport function, developed commercial and residential development around stops and intermodal nodes. This direction of the port's influence on the development of coastal areas refers to the historically established function of city-forming and region-forming transport to other spatial development structures;
- Airport Region, the scope of which determines the relations with the airport, signed with an isochron of a 2-hour journey to the airport or an isoline to 90 km of spatial distance. It is an area shaped by the flows of people, goods and cash;
- Airport Area are prestigious locations of entities in a city or region related to air transport, e.g. consortia (plants) of aviation companies, developers and providers of software for aviation and logistics companies, agencies and air ticket distribution offices (also for transport/coach service of passengers' needs organized by airports), international corporations significant for aviation operations or state aviation institutions[19].

J. Kasarda's classification is the authorial work of the beginning of the second decade of the 21st century, but the time and capital intensity of investment processes

[17] J. Kasarda, G. Lindsay, *Aerotropolis…*; M. Stangel, *Airport City. Strefa okołolotniskowa jako zagadnienie urbanistyczne*, Helion, Gliwice 2014, p. 44.

[18] M. Stangel, *Airport City…*, p. 44.

[19] J. Schlaack, *Defining the Airea. Evaluating urban output and forms of interaction between airport and region* [in:] *Airports in cities and regions: research and practice,* eds. U. Knippenberger, A. Wall, 1st International Colloquium on Airports and Spatial Development, Karlsruhe, 9–10 July, 2009; M. Stangel, *Airport City...*, p. 44.

in large-scale landside areas is about the durability of model transformations. Practice also shows that the development of these areas sometimes proceeds selectively in an individual way for different airports (e.g. public spaces around some of the regional airports in Brazil are adapted almost exclusively to the needs of the tourist traffic)[20].

The landside areas are characterized by determined economic activity, including: main – aviation (technical, related to the use of branches air traffic service) and non-aeronautical, but focused on extended economic cooperation with the airport[21]. This localization is interesting for entities of air services or often using air services, others – satisfying the additional needs of the two groups of entities mentioned above, as well as those interested in using infrastructural areas, not always aviation services, e.g. B+R sector (science and technology parks, start-ups, conference and educational centers), companies of the so-called BPO/SSC sector[22], conducting industrial activities (special economic zones, industrial parks), commercial (business and office complexes of the "Flex-Tech" type), service type (TSL, parking, hotels and catering, duty-free shopping centers, wholesale, retail), insurance, banking, insurance, customs warehouses, settlement structures[23].

4. Determinants of the location and functioning of landside areas – selected aspects, research results and discussion

Contemporary trends in the development of landside areas encourage redefinition of their perception as separate spatial structures around aviation facilities. These are structures about the new subject matter of the urban commercial space and the development trend of the urban and regional development structures[24]. They are common around large US airports with a tendency to adapt to smaller airports in the world, aspiring to benefit from the activities of the immediate environment.

The primary determinant of the economic development of air transport and space around the world is demography and an increase in the population reporting the demand for air services. Its dynamics sanctions the influence of branches on the development of the surrounding space and investment recovery on the basis of the needs and usefulness of only one branch of transport.

Another determinant of launching investment projects is the natural location specifics of the economic landside areas, land and water costs. In addition to local assets (topography and location), free land is included for economic use correlated

[20] A.M. Elisangela, P. Silva, P. Marcelo, A.A. Queiroz, S.J. Fortes, *Establishing a priority hierarchical for regional airport infrastructure investments according to tourism development criteria: a brazilian case study*, https://www.academia.edu/35710059/ (access: 4.04.2018).

[21] M. Güller, M. Güller, *From Airport to Airport City*, Barcelona 2003, from: M. Stangel, *Airport City...*

[22] The so-called BPO/SSC sector (Business Process Outsourcing and Shared Service Center) – implementation of business processes for corporate clients from around the world.

[23] J. Kasarda, G. Lindsay, *Aerotropolis…*

[24] P. Lorens, *Tematyzacja przestrzeni publicznej miasta jako wynik współczesnych procesów rozwoju urbanistycznego* [in:] *Regiony nadmorskie 12. Wybrane problemy przekształceń miast Polski Północnej*, ed. M. Pacuk, University of Gdańsk, Gdańsk–Pelplin 2006, p. 105–119.

with the specific needs of airports. As a result, their existing order changes – from open spaces to compact development in the immediate and further vicinity of the terminal, development of communication routes to spatially dispersed objects relative to the port or airport. The value and prices of land in the surrounding areas are a locational rent, paid by investors and natural persons interested in acquiring a preferred location in conditions of limitation or shortage of areas around the airport for commercial development.

The primary determinants of the development of landside areas include airports, their economic priorities and development initiatives. More recently, plans to modernize these facilities and build new airports include business models for the creation and use of landside areas. Other factors are also noteworthy, including the individually diversified scale of airport operations or location specifics. This mainly applies to newly emerging airports for which landside areas are elements of strategy and master plans for their creation (including Beijing Capital International Airport, Kuala Lumpur International Airport, Singapore Changi Airport, Incheon International Airport, Hong Kong International Airport, Shanghai Pudong International Airport, Bangkok Suvarnabhumi Airport, others). At the Asian and Australian airports (Indian, Indonesian, Brisbane, Halim Perdanakusuma Airport, Sydney Airport, Melbourne, Canberra Airport, Darwin Airport and many others) with a strong increase in air traffic, almost equal attention is paid to the development of their landside and logistics facilities. The logistic determinant is important for modeling the functions of small airports, post-military airports, not involved in regular air transport, e.g. in Poland – Przemyśl-Arłamów, Stary Sącz, Piła, and others.

The infrastructural determinant determines the evolution of the landside areas. Transport infrastructure conditioning accessibility, reduction of transport costs, its usefulness and quality (also of energy, water, communication and media systems) is an essential element of technical equipment and location advantage of these areas[25]. Location and transport accessibility is also an important image factor of airports and their surroundings (marketing determinant)[26]. Their location on the outskirts of city requires efficient transport connections, correlated with the functioning of urban areas. Criteria for such service are met by modern inter-branch transport integration solutions that reduce unwanted congestion and external transport costs. Instead, they determine their effective use, social mobility, environmental conditions and a rational division of transport tasks[27]. The most frequently indicated are the advantages of rail transport (mass, reliability, regularity, pro-ecological character). This corresponds to the concept of AirPort Link, the development of intermodal airport connections with city centers, increasing the transport accessibility of destinations, comfort, travel safety, the possibility

[25] The timeless transport factor has been permanently connected with the theory and practice of locating economic activity since the 19th century, somehow overriding other location factors (distribution of production and markets, quality and efficiency of production factors, price levels, taxes, investment incentives, political stability, foreign investments and regional political climate).

[26] Based on primary research carried out at the Department of Transport Market at University of Gdańsk in 2017.

[27] L. Laplace, N. Lenoir, F. Pita, I. Rebello, A.Valadares, *WP1-Review of the current intermodality situation*, EUROCONTROL CARE INO project: The airport of the future: Central link of intermodal transport?, M3 SYSTEMS, ANA, ENAC-AEEL, 2004.

of reducing their costs, shortening travel times, reducing the scale of environmental degradation and independence from weather conditions. According to the Railway Institute, effective organization of railway connections with landside areas reduces the travel time to 50%, taking over 40% of traffic. According to the International Air Rail Organization (IARO), the AirPort Link concept was implemented in about 80 airports around the world and was planned for further 230. The development of AirPort Link is associated with the expansion of air transport, the construction of interchange and integration nodes at railway stations and intermediate points at their routes[28]. The system is used by the European airports in Cologne, Zurich, Rome-Fiumicino, Charles de Gaulle in Paris, Madrid-Barajas, Amsterdam Airport Schiphol, London Haeathrow, Brussels-National or Zaventem, Munich Airport, Copenhagen-Kastrup (metro line), Malaga Airport, Arlanda Express in Stockholm, and in Poland – airports in Warsaw, Krakow and Gdansk.

The tool for implementing regional policies, airport development strategies and entities operating in landside areas is the political determinant. Its significance increases in a confrontation with the geopolitical location of these areas and the implementation of strategic economic policy plans.

The economic determinant constitutes the efficiency of management and achieving extraordinary benefits from the location of operations on the infrastructure-financed area. When making location decisions in landside areas, attention is drawn to the value and prices of land to be developed in terms of costs for investors and location rent for sellers/leases, the amount of which depends on the detailed location, the available area and the attractiveness of the airport. The amount of investment capital, project costs and the account of their effectiveness are also important. The economic benefits (also disadvantages – agglomeration costs) result from the agglomeration of activities and cooperation of entities, while being the subject of systematic research and analysis. The accessibility of air transport accelerates the export and import of labor resources, product sales, international contacts and exchange of experience. However, one should remember about the costs of restitution of the state of the environment. The market determinant, including marketing and diagnosing the competitive environment of the entities, determines the market relations of the economic and territorial competitiveness, favors creating the image value of organizations, cities and regions.

At each stage of the development of landside areas, the determinant of development are transparent formal, legal and administrative regulations. In Poland, there are statutory regulations on spatial planning and development[29], the Aviation Law[30], the Construction Law[31], the Environmental Protection Law, contained in executive acts, ecological reviews and environmental impact assessments[32], local laws and other documents entitling to invest in the vicinity of airports. The objectives and tasks to be achieved result from the spatial development strategy

[28] www.iaro.com (access: 13.03.2018).

[29] Act of 27 March 2013 on spatial planning and development (Journal of Laws of 2003, item 717).

[30] The Aviation Law from July 3, 2002 (Journal of Laws of 2002, No. 130, item 1112).

[31] The Act of 7 July 1994 Construction Law (Journal of Laws of 2017, item 1332, 1529, from 2018, item 12, 317, 352).

[32] The Act of 27 April 2001 on Environmental Protection Law (Journal of Laws of 2013, item 1232, with changes).

of the regions, the development of air transport, airport development programs and plans. The Aviation Law emphasizes for the indication and marking of objects (natural or man-made) in the vicinity of airports, limiting the safety of air operations and posing a threat in the vicinity of the point infrastructure of branches[33].

The socio-cultural determinant is a reflection of the idea of shaping a public space in the landside areas, which constitutes their "climatic" and functional attractiveness. It is an objective economic category, determining the price of space and market value of the location, perpetuating the development trend under the slogan "landside areas friendly for people".

5. The dysfunction of landside areas

The source of spatial conflicts in the landside areas may be dysfunctional land use. Peripheral locations can generate specific spatial relations, including architectural dissonance between modern and existing buildings, hindering the planned development of landside areas due to the "unevenness of spatial relations between urban, suburban and rural buildings"[34]. The source of spatial conflicts may also be the distance of airports from city centers (agglomerations) and insufficient transport connections. The research confirms the interdependencies between the location, distance and duration of air travel, while the longer air travel reduces negative relations of time and space. Mitigation of such situations remains at the discretion of various entities, including branch carriers, transport organizers and airlines developing transport offers and network connections.

Environmental aspects (environmental determinant), including aircraft noise, are the dysfunction of areas. Airports have the power to formally limit the operating time of airports, and local governments, to identify areas of limited use of OOU, which have been designated for the majority of airports in Poland[35]. The current activities in this area also include anti-noise procedures for take-offs, departures, approaches and landings, setting noise reduction zones around airports or minimum noise routes, special constructions of infrastructure components of airports, environmentally friendly test procedures, earthworks, acoustic screens, belts greenery, airport silencers, etc., actions to eliminate the causes of noise within the propulsion systems of aircraft. The emission level of harmful substances in flue

[33] These include: limiting the opportunities for feeding birds in areas adjacent to airports by prohibiting the construction, development or creation of favorable conditions including their breeding. In both cases, the restrictions apply to the area within 5 km from the airport borders and should be taken into account at the investment planning stage.

[34] P. Trzepacz, M. Luc, *Użytkowanie ziemi w sąsiedztwie portów lotniczych Polski*, https://www.academia.edu/18863762/U%C5%BCytkowanie_ziemi_w_s%C4%85siedztwie_port%C3%B3w_lotniczych_Polski (access: 24.03.2018).

[35] Areas of limited use are provided for by the provisions of the Act of April 27, 2001. Environmental protection law (Journal of Laws of 2008, item 25.150, as amended). They were introduced by resolutions of the Local Government Seymes of some provinces. The designation of the area is a natural consequence of the development of airports, airports and the increase in the number of air operations. From the point of view of the airports, OOU is determined by objective technical criteria, while in the relation between the airport and spatial planning – they constitute the order and stabilization of the legal situation of the real estate located within their range.

gas from aircraft engines is low and their impact on the atmosphere less harmful than many other industries. One of the methods of reducing harmful emissions is also the modification of combustion chambers of aviation fuel.

Conclusions

Contemporary landside areas are characterized by the unique usefulness of locally and functionally attractive space, the comprehensiveness of adaptation of technological, management and spatial achievements as well as modeling of socio-economic relations. They are qualified for strong determinants of the targeted development of urban and regional functional space development structures. Airports and their surroundings distinguish synergistic developmental and economic interdependencies with the environment. The presented determinants of development of landside areas provide the basis for redefining their previous perception as separate spatial structures. It is also difficult to unambiguously prioritize them – all of them are important for the proper development and operation of airports and related environments. Demographic and economic processes start investments, transfer of urban functions to the areas of airports and conditions of adaptation of solutions, which should be friendly to all users. The beneficial effects of the synergy of goals and functions are revealed in the field of economy, management, organization, market, architecture of space and housing development. The economic effects obtained extend the list of determinants of achieving further growth in location, investment and economic efficiency as well as the benefits of agglomeration. There is an increase in aviation and accompanying activity. These complexes quickly become strong stimulators of territorial development, competitiveness of airports and surrounding areas.

However, environmental conflicts lead to consider the verification of some decisions, among others concerning the development of housing areas in the vicinity of airports. The assumed increase in aviation activity, despite mitigation measures, will increasingly generate environmental nuisances for all users of the analyzed areas, including their inhabitants. In this dimension, the desirability of limiting the residential function as an element of Airport Cities should be suggested. However, due to the favorable infrastructural, economic and market effects of economically active entities, development of landsided areas is justified, which is also confirmed by the results of primary research. For example, around Gdańsk Lech Walesa Airport by 2025 is expected to create a commercial zone with an area of up to 200 000 m^2, which means 20 000 new jobs.

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ENVIRONMENTALLY RESPONSIBLE MANAGEMENT OF TRANSPORT OF GOODS IN URBAN AREAS

Abstract

The aim of the article is to present the possibility of taking into account environmental aspects in managing the transport of goods in urban areas. The article presents the ICT system built within the framework of the international S-mile project, which may support both decision-making including environmental aspects in relation to institutions organizing the transport system of a particular area, as well as supporting environmentally responsible attitudes towards local freight carriers. The individual modules and interactions between the stakeholders of the system are also briefly characterized.

Keywords: environmental responsibility, transport planning, transport of goods, freight transport management

Introduction

The transport system, like every system, is a deliberately organized whole as a coordinated arrangement of elements, a set conditioned by a constant, logical ordering of its components, so that changing one element can affect the other elements of this system. That is why it is so important to identify negative phenomena whose interference in the structure of a particular area and the quality of life of residents should be minimized. In relation to transport in general, six basic aspects of negative impact on the environment can be distinguished – safety, congestion, energy consumption, land use, emission of harmful substances and noise. The transport of goods plays a special role in the impact on the environment due to its specificity. Transport of goods, carried out over long distances, close to the destination (in the urban area) often requires a change of means of transport, due to transport network constraints or lack of transport accessibility for large trucks in city centers.

The delivery of goods then often forces the use of the local market of final carriers. Large companies providing transport services or production companies at the stage of the so-called first and last mile problem[1] face problems related to, among others with little knowledge of the limitations of the urban transport network, including local difficulties caused by congestion (dynamics of daily and periodic changes resulting from specific local causes) or the quality of the road surface, as well as the increase in transport costs of the first and last mile due to the lack of full information about the services market in this regard. At the same time, there is still a lack of use of environmental criteria in the planning of transport of goods, both on the carrier (and specific journeys), and due to the planning of the transport system by local authorities. In the latter case, the reason is often the lack of tools for collecting data on the transport of goods[2].

The aim of the article is to present the possibility of taking into account environmental aspects in managing the transport of goods in cities. The problem is presented both in relation to a single transport company and local authorities. A comprehensive ICT solution was proposed to support decision making called S-mileSys, which is an IT system that is one of the results of the international project "Smart platform to integrate different freight transport, manage and foster first and last mile in supply chains (S-miles)" in ERANET Transport III co-financed by the National Center for Research and Development. Apart from the integration of three stakeholder groups (large transport companies, local carriers and local authorities), this tool takes into account environmental problems (in the form of three indicators identifying the impact of transport on the environment) at the stage of transport planning, while allowing simulation of goods transport in the city. Thanks to the feedback channel, the system administrator (local authority or other decision-making entity) receives data on the actual transports carried out and the possibility of transport simulation with the assumption of organizational changes. Such an approach allows in the long-term perspective to support the decision-making process in the area of traffic flow management (including transport of goods).

The article presents the basic modules of the S-mileSys system. Particular attention was paid to the planning stage, which requires the use of several optimization algorithms (among others in terms of route, selection of vehicles from the available fleet, the distribution of loads on vehicles and the distribution of cargo in the vehicle, etc.). Taking into account environmental criteria allows to limit the negative impact of transport on the environment. Planning transporting goods requires a considerably larger number of criteria to be taken into account than the planning of travellers' routes. A comprehensive fleet management platform together with a planning module, combined with other modules of the S-mileSys system being built, is also aimed at integrating large transport companies with first and last mile carriers.

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[1] *Logistyka. Nauka – Badania – Rozwój*, ed. M. Mindur, Scientific Publisher of the Institute for Sustainable Technologies – PIB, 2017.

[2] K. Kijewska, K. Małecki, S. Iwan, *Analysis of Data Needs and Having for the Integrated Urban Freight Transport Management System*, Communications in Computer and Information Science 2016, 640, p. 135–148.

1. Characteristics of the S-mileSys system and its assumptions

The problem of transporting goods in urban areas requires a multi-faceted look. Direct transport contractors, i.e. local carriers, create difficulties in changing the load on the transport network during the day, as well as the need to plan transport in an efficient manner. Information on the offer of local carriers, in turn, is required by large carriers (with domestic or international transport range) and producers. The third type of stakeholders are local authorities and institutions that influence the shape of the transport system in a particular area. In this case, the essence of the problem is the proper shaping of traffic flows on the transport network, which should also take into account future development plans and, to a large extent, environmental responsibility. In the S-mile project, an important emphasis was placed on pro-ecological solutions. Limiting the negative impact on the environment can be achieved, among others, through: improvement of transport performance, i.e.[3] optimization of routes and supply chains; taking into account the environmental criterion during transport planning, promoting environment-friendly carriers as well as infrastructure and organizational changes in the transport system.

The basic product of the S-mile project is the IT system (S-mileSys) supporting multimodal transport for the first and last mile, promoting transport and pro-environmental solutions. This system takes into account ecological criteria at the stage of route planning, which makes it possible to estimate the impact of transport of goods on the environment and on the health of residents. Among the criteria, the quality of transport was also taken into account. The system also supports the creation of road network quality maps and offers full information regarding the availability of various transport companies (local carriers) to the system's customers. The system operates on the principle of registered access to the cloud and is supported by the use of web services. Six basic elements of the system were distinguished[4]:

– S-mile Market Tool: this tool is a link between customers (large transport companies, manufacturers, logistics centers, etc.), and local carriers carrying goods for the first and last mile. The module resembles the functionality of a transport exchange, which in this case is assigned to a specific geographical area. The customer, by filling in an appropriate electronic form, can send an inquiry.

[3] Among others: White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM(2011) 144; White Paper on the Future of Europe, Reflections and scenarios for the EU27 by 2025, COM(2017) 2025; Clean Power for Transport: A European alternative fuels strategy, COM(2013) 17; Sustainable Logistics and Supply Chains: Era-net Transport Flagship 2015 Call, 2015; M. Jacyna, J. Żak, I. Jacyna-Gołda, J. Merkisz, A. Merkisz-Guranowska, J. Pielucha, *Selected aspects of the model of proecological transport system*, Journal of KONES 2013, Powertrain and Transport, 20, p. 193–202; B. Tundys, *The Impact and Role of Transportation on the Construction and Operations of the Green Supply Chain* [in:] *Sustainable Transport Development, Innovation and Technology*, ed. M. Suchanek, Springer Proceedings in Business and Economics, Springer, Cham 2017, p. 15–26; B. Galińska, *Multiple Criteria Evaluation of Global Transportation Systems – analysis of case study* [in:] *Advanced Solutions of Transport Systems for Growing Mobility*, ed. G. Sierpiński, Advances in Intelligent Systems and Computing, vol. 631, Springer, Cham 2018, p. 155–171.

[4] M. Staniek, G. Sierpiński, *Smart platform for support issues of first and last mile in the supply chain – the concept of the S-mile project*, Scientific Journal of Silesian University of Technology. Series Transport 2016, 90, p. 11–21.

Market Tool selects from the available list of companies those that meet the criteria of the query and forwards the form to the next system modules. Finally, in response, he sends the client an offer to fulfill his order by carriers from the system;
– S-mile Freighter Tool is the main element of S-mileSys dedicated carrier. It has the ability to monitor the fleet and supporting the communication module. The tool is responsible for maintaining information on the current availability of the carrier's fleet and its location. It also watches over the plan of scheduled transports;
– S-mile Fleet Management Tool is a tool supporting carrier's decisions through algorithms of optimal distribution of goods and determination of transport costs;
– The S-mile Transport Planner Tool helps you determine the optimal routes of supply chains. The optimization is based on several criteria, including time, distance, cost and three environmental criteria. This system tool at the planning stage also takes into account the current level of congestion (with the use of internal, as well as the possibility of attaching external sources of information) and the quality of the road network. The quality of roads is monitored by an independent system module using directly the transport of carriers' vehicles;
– S-mile Visualizer Tool is available to local authorities (in the full range of data) and to carriers (access only to the carrier's data). This tool enables visualization of information collected during system operation. This applies to both the quality of roads and the distribution of transported goods to the road network. This element of the system allows you to perform a full overview of the area in terms of historical journeys with the goods. On this basis, local authorities may decide to introduce restrictions on heavy traffic in a specific part of the city or to enter access only for electric vehicles;
– S-mile Simulation Tool is intended for use by local authorities and other decision-making bodies. It is a multiagent simulator based on the existing base of carriers from S-mile Market Tool. This tool makes it possible to assess the impact of various changes introduced in the analyzed area in terms of incentives and restrictions on the implementation of transport of goods, and as a result allows to assess the impact of such changes on the environment and human.

2. Criteria for planning transport of goods and the need to increase environmental responsibility

Transport planning allows you to consider several possible variants of the supply chain and make the optimal choice depending on the additional internal factors of the carrier. Existing support tools, such as travel planners, intended for travelers allow you to choose ways of moving between two (or more) points using one or more modes of transport in the displacement chain. In the case of transport of goods, the basic functionality of the travel planner is not sufficient to maintain high efficiency of transport. This requires a much more extensive integrated IT platform that supports and optimizes carrier decisions. The lack of compatibility of the standard for data exchange, however, means that local transport companies

use very different systems, which hinders integration and requires the adaptation of large carriers (interested in cooperation at the first and last mile stage) to various IT systems. Still, the majority of carriers do not pay attention to the environment, conditioning the transport of goods only with the criterion of cost and time (or a criterion based on both parameters with appropriate weights)[5].

Planning transport of goods in supply chains differs from planning individual journeys between source and destination. In this case, effective planning should consider substantially more parameters. The following modules participate in the S-mileSys tool in the travel planning process: Vehicle assignment optimization algorithm (connected with the proper distribution of goods), Freight transport cost calculating Tool (allowing you to estimate transport costs), Emission factor Tool (containing algorithms that estimate the negative impact on environment), Routing algorithms (related to the search for optimal routes) and Database for route planning (in the form of an archive of data on the transport network).

Optimal distribution of goods in a vehicle depends on many factors, including the size and shape of individual items of cargo, but also the order of delivery[6]. The second problem of the distribution of goods is the optimal allocation of cargo to the owned and currently available fleet of the carrier[7]. Another element in the described ICT system is an extensive cost calculator taking into account, among others, operating and personal costs, costs related to fleet maintenance, storage costs (in the case of storage of goods), etc.[8]

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[5] In the literature you can find comparisons comparing current solutions in this area, as well as few proposals for travel planners taking into account the environmental aspect, among others P. Borkowski, *Towards an Optimal Multimodal Travel Planner – Lessons from the European Experience* [in:] *Intelligent Transport Systems and Travel Behavior*, ed. G. Sierpiński, Advances in Intelligent Systems and Computing vol. 505, Springer, Cham 2017, p. 163–174; D. Esztergár-Kiss, Cs. Csiszár, *Evaluation of multimodal journey planners and definition of service levels*, International Journal of Intelligent Transportation Systems Research 2015, 13, p. 154–165; D. Földes, Cs. Csiszár, *Route Plan Evaluation Method for Personalized Passenger Information Service* Transport 2015, 30(3), p. 273–285; K. Lewczuk, J. Żak, D. Pyza, I. Jacyna-Gołda, *Vehicle Routing in Urban Area – Environmental and Technological Determinants*, WIT Transactions on The Built Environment 2013, 130, p. 373–384; G. Sierpiński, *Technologically advanced and responsible travel planning assisted by GT Planner* [in:] *Contemporary Challenges of Transport Systems and Traffic Engineering*, eds. E. Macioszek, G. Sierpiński, Lecture Notes in Network and Systems, vol. 2, Springer, Cham 2017, p. 65–77; M. Maciejewski, *Dynamic Transport Services* [in:] *The Multi-Agent Transport Simulation MATSim*, ed. A. Horni, K. Nagel, K.W. Axhausen, Ubiquity Press, London 2016, p. 145–152.

[6] Among ohers: D. Pisinger, J. Egeblad, *Heuristic approaches for the two- and three-dimensional knapsack packing problems*, DIKU Technical-report no. 2006-13, University of Copenhagen 2006; K. Popiela, M. Wasiak, *A method of loading unit formation taking into account mass, load-bearing strength and surfaces of packing units*, Scientific Journal of Silesian University of Technology. Series Transport 2017, 96, p. 151–160.

[7] Among others: Y. Shen, Q. Nie, Q. Yuan, X. Yang, *Study on express delivery service provider configuration by applying a synthetic method*, 1st International Conference on Information Science and Engineering 2009, p. 4514–4517; V. Naumov, *Estimating the Vehicles' Number for Servicing a Flow of Requests on Goods Delivery*, Transportation Research Procedia 2017, 27, p. 412–419.

[8] Similar cost models were used, inter alia, in the work of: M. Bąk, *Koszty i opłaty w transporcie*, University of Gdańsk Publisher, Gdańsk 2010; M. Berwick, M. Farooq, *Truck Costing Model for Transportation Managers*, Upper Great Plains Transportation Institute North Dakota State University 2003; G. Karoń, R. Janecki, *Concept of Smart Cities and Economic Model of Electric Buses Implementation* [in:] *Telematics – Support for Transport*, ed. J. Mikulski, Communications in Computer and Information Science, vol. 471, Springer, Berlin–Heidelberg 2014, p. 100–109.

One of the goals of the S-mile project is to promote environmentally responsible solutions. On the basis of European and world literature[9], several emission factors were defined. After further analysis, due to the need for the carrier to understand the message, in addition to the traditional criteria for optimizing the route over time, distance or cost, the S-mileSys system implemented an additional three criteria (as a generalized impact on the environment) aimed at seeking solutions to reduce the harmful impact transport to the surroundings[10]. For each criterion a separate value estimation model was built, however all of them were based on the following basic variables[11]:

$$CC, DALY, NOISE = f(VT, RT, S, TC, G, L, A),$$

where:
CC – impact on climate change [CO_2eq/km];
DALY – an indicator describing the expected loss of health or life caused in this case by transport (disability adjusted life-years) [daly/km];
NOISE – vehicle noise emission [dBA];
VT – vehicle type (classification by vehicle type, e.g. electric car, passenger car, commercial vehicle, lorry, etc.);
RT – road type;
S – speed [km/h], the parameter determines the speed at each section of the transport network (referring to the permissible speeds on sections and speeds recorded from traffic monitoring functioning in a given area of Intelligent Transport Systems – ITS);
TC – traffic volume [–], a parameter that takes into account the current or forecast traffic on individual sections of the transport network (data collected by S-mileSys or external data from traffic monitoring functioning in a given ITS area);
G – road lean [degrees];
L – load [–], the parameter determines the degree of loading the vehicle with a commodity;
A – fixed residual value.

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[9] Among others: M. Maibach, C. Schreyer, D. Sutter, H.P. van Essen, B.H. Boon, R. Smokers, A. Schroten, C. Doll, B. Pawłowska, M. Bąk, *Handbook on Estimation of External Costs in the Transport Sector. Internalisation Measures and Policies for All external Cost of Transport (IMPACT)*, Delft 2008; H.P. van Essen, A. Schroten, M. Otten, D. Sutter, C. Schreyer, R. Zandonella, M. Maibach, C. Doll, *External costs of transport in Europe. Update Study for 2008*, Delft 2011; *The Calculation Of External Costs In The Transport Sector. A Comparative Analysis of Recent Studies in the Light of the Commission's 'Greening Transport Package'*, European Parliament's Committee on Transport and Tourism, Brussels 2009; U.J. Becker, T. Becker, J. Gerlach, *The True Costs of Automobility: External Costs of Cars Overview on existing estimates in EU-27*, Dresden 2012; B. Pawłowska, *Zrównoważony rozwój transportu na tle współczesnych procesów społeczno-gospodarczych*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2013; A. Korzhenevych, N. Dehnen, J. Bröcker, M. Holtkamp, H. Meier, G. Gibson, A. Varma, V. Cox, *Update of the Handbook on External Costs of Transport*, Final Report. Ricardo-AEA/R/ ED57769, Oxford, Didcot 2014.

[10] S-*mile Report D4.1 Emission factor calculation tool*, Smart platform to integrate different freight transport means, manage and foster first and last mile in supply chains, Bilbao 2016.

[11] The constructed model of estimating the impact of goods transport on the environment is based on guidelines and databases, among others: *Handbook of Emission Factors for Road Transport* (HBEFA Version 3.2), 2014 and *The Noise Navigation Sound Level Database* (NNSLD), E•A•RCAL Laboratory, 2015. The model needed to be calibrated and implemented into the form of programming libraries A. Pijoan, I. Oribe-Garcia, O. Kamara-Esteban, K.N. Genikomsakis, C.E. Borges, A. Alonso-Vicario, *Regression Based Emission Models for Vehicle Contribution to Climate Change* [in:] *Intelligent Transport Systems and Travel Behaviour*, ed. G. Sierpiński, Advances in Intelligent Systems and Computing, vol. 505, Springer, Cham 2017, p. 47–63.

Using the described S-mileSys tool, the carrier receives a report with a list of optimal solutions for various optimization criteria. Depending on the chosen criterion, the S-mileSys system implemented in the S-mileSys algorithm will minimize distance, time, costs or negative impact on the environment by searching the set of R routes between individual pick-up/delivery points selected for the supply chain for a specific type of measure transport:

$$R = \{r_i: r_i(T, D, C_T, EI\ (CC, DALY, NOISE))\} \qquad \underset{criteria}{Opt} = \min\ (r_1, r_2, \ldots, r_n),$$

where:
R – a set of routes between selected points of the transport network;
T – travel time [h];
D – distance [m];
C_T – total cost [cost unit];
EI – impact on the environment determined by selected from emission factors;
Opt – objective function.

It should be noted that depending on your vehicle fleet, the planning algorithm for supply chains in the S-mile Transport Planner Tool takes into account additional transport infrastructure parameters, such as availability for a specific type of vehicle (e.g. some infrastructure elements may be impassable), location of parking spaces near the destination (in the case of small shipments), range of the vehicle, quality of the road, etc.[12] The S-mileSys IT system also includes various types of transport, including electric vehicles, as an alternative to conventional solutions.

3. Example of support for the carrier and local authorities in the field of freight transport management

The S-mileSys system is addressed to three groups of stakeholders. Relations in the S-mileSys IT system affect two groups of users – local carriers, whose environmental awareness may increase thanks to the use of S-mileSys and authorities affecting the shaping of the city's transport system, for which the tool is a source of information on transport of goods and support in making decisions to reduce the negative impact of goods transport on the environment.

As soon as all transport parameters have been agreed with a specific group of customers using the S-mile Market Tool element (and determining the optimal route), the carrier begins transporting the goods at the last mile stage. In this case, the following activities are carried out all the time (Figure 1):

– the carrier through the Freighter Tool has an overview of the current state of its rolling stock (location and transport plans), and can take current corrective action (1);

[12] M. Staniek, *Road pavement condition as a determinant of travelling comfort* [in:] *Intelligent Transport Systems and Travel Behaviour*, ed. G. Sierpiński, Advances in Intelligent Systems and Computing vol. 505…, p. 99–107.

– Fleet monitoring module constantly monitors the position of vehicles and enables the transmission of optimal routes and navigation instructions to mobile devices in vehicles (2);
– in the event of difficulties in the transport of goods (notification by the driver), for example due to the occurrence of a congestion, road accident or vehicle carrier failure, procedures are implemented to restart individual Fleet Management Tool and Transport Planner Tool necessary in the optimization process routes and assignment of goods to vehicles for reported additional restrictions (3);
– a separate activity is the acquisition of data from the carrier's vehicles using the Road condition tool (4). These data concern the condition of the road network surface and, after appropriate processing, constitute the basis for further planning of routes taking into account the quality of transport. Collecting the above data does not require any interference by the driver – the system registers and sends them remotely. The speed and exact route of the vehicle are also recorded (with additional parameters set, such as the weight of the vehicle and the load being carried).

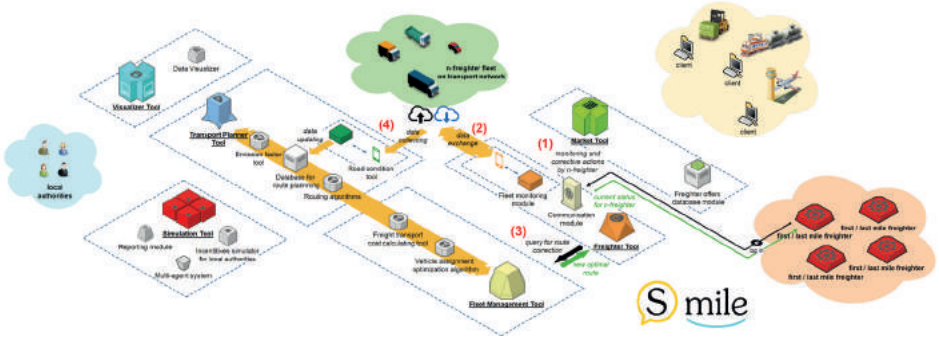

Figure 1. Visualization of the carrier – S-mileSys system interaction related to the transport of goods
Source: own elaboration

The S-mileSys system supports making decisions of local authorities and other decision-making entities in the scope of organizational and infrastructural activities by providing insight into the current status of goods transport in a selected area (visualization of the historical distribution of traffic flows) and simulating the functioning of goods transport within the city. Figure 2 illustrates the use of the scenario simulation tool related to the implementation of various Simulation Tool initiatives:
– local government requests for proposals with a specific initiative (1) for Simulation Tool;
– sending the complete carrier database from Market Tool to simulation modules (2), which allows to simulate the transport of goods based on existing companies and their actual parameters;
– obtaining optimal routes according to various criteria from the Transport Planner Tool (including emissions, noise, road conditions, costs, time and distance) (3);

– launching the Multi-agent system[13] and executing simulation of goods transport for the current state, and then simulating again (Incentives Simulator for local authorities module) for the proposed changes. The final analysis of the data generates a report (4) that supports decision making. An example of a simulation window is shown in Figure 3.

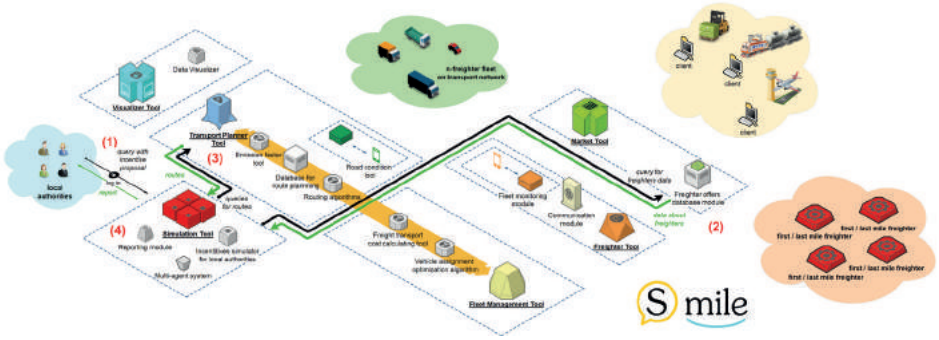

Figure 2. Visualization of the interaction of local authorities – S-mileSys system related to the assessment of the effects of introducing changes in the transport system
Source: own elaboration

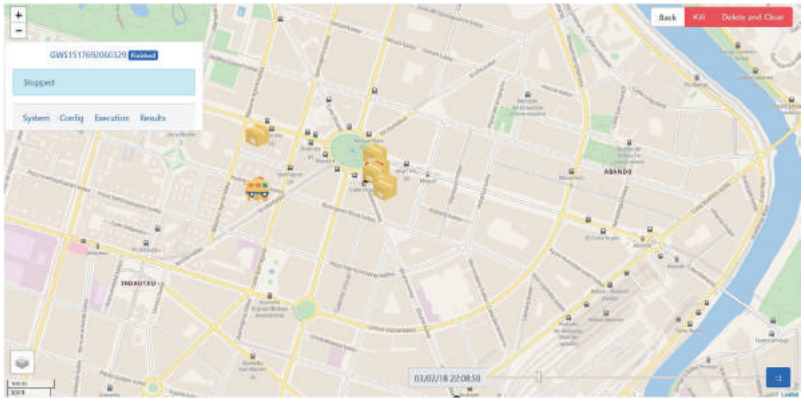

Figure 3. Window of the S-mileSys simulation tool
Source: *S-mile Report D6.3 Multi Agent System*, Smart platform to supply, Bilbao 2017

[13] The described multiagent system has been implemented, among others in: A. Pijoan, O. Kamara-Esteban, I. Oribe-Garcia, A. Alonso-Vicario, C.E. Borges, *GTPlat: Geosimulation for Assessing the Application of Incentives to Transport Planning* [in:] *Advanced Solutions of Transport Systems for Growing Mobility*, ed. G. Sierpiński, Advances in Intelligent Systems and Computing, vol. 631…, p. 74–89.

Conclusions

The environmentally responsible IT management of goods transport is a challenge for the efficient functioning of the modern city. Such management should be carried out both at the level of the undertaking performing transport of goods (optimal transport planning) and with the use of organizational and legal activities by local authorities and institutions shaping the city's transport system. If used on a larger scale, the described solution in the form of the S-mileSys system can change the way of transporting goods in cities. Taking into account environmental criteria allows to limit the negative impact of transport on the environment. A comprehensive fleet management platform along with a planning module in conjunction with other S-mileSys systems is also aimed at integrating large transport companies with first and last mile carriers.

As part of further research, it is planned to try to integrate the S-mileSys system with the result of another project – GTPlat – a platform supporting the travel of people in cities. Such an approach, especially in reference to simulation modules, enables more accurate analysis of the functioning and possibilities of changes in the city's transport system.

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METHOD FOR EFFECTIVENESS ASSESSMENT OF ROLLING STOCK INVESTMENTS USING LCC (LIFE CYCLE COST) ANALYSIS

Abstract

The article concerns the application of LCC (Life Cycle Cost) life cycle analysis as a method of assessing the effectiveness of investments in rail transport. On the basis of general guidelines contained in professional literature and international standards, including PN-EN 60300-3-3:2017-07, the LCC calculation method for rail transport is presented. This method can be used to assess the effectiveness of various variants of purchasing new vehicles, as well as to compare the costs of their modernization.

Keywords: effectiveness assessment, LCC analysis, rail transport

1. Methods for effectiveness assessment of investments in rail transport

Legal conditions in the field of rail transport in Poland allowed for the dynamic development of private business entities dealing with rail transport of cargo and passengers. In recent years, the railway market has seen a lot of interest in the purchase of new passenger transport vehicles: electric locomotives, traction units, as well as the modernization of old rolling stock for freight transport, mainly of diesel locomotives. Due to the very high costs associated with investments related to the purchase or modernization of rail vehicles, these projects should be carefully analyzed in terms of feasibility and cost-effectiveness. The effectiveness assessment of investment projects related to railway means of transport has the character of a relative, microeconomic calculus – performed from the railway enterprise (railway carrier, manufacturer, modernization contractor), which incurs

certain investment expenditures on the purchase or modernization of rolling stock, operating costs and benefits from the implemented transport services. Conducting a reliable assessment of effectiveness requires comparison of several investment variants that correspond to specific technical solutions[1]. The selection of the methods of researching the effectiveness of investment projects developed so far and applied in practice depends on the individual characteristics of the undertaking[2]. Based on the experience gained during the implementation of research and development works for Polish rail carriers[3], the following methods may be used to assess the efficiency of rolling stock:

– Cost-Benefit Analysis;
– Life Cycle Cost Analysis.

These are the methods recommended in international standards, including: in the UIC 345 Environmental specifications for new rolling stock, in the PN-EN 60300-3-3 standard:2017-07 Reliability management. Part 3-3: Application Guide – Life cycle cost estimation, recommended by the World Bank and the United Nations Industrial Development Organization (UNIDO).

2. The proposed method of LCC life cycle cost analysis

Numerous methods of calculating the lifecycle cost are proposed in the literature and in the proposed standards[4]. The choice of the right model depends on the resources available, the input data available, the time horizon that the analysis includes, the accuracy of the calculations and the object being analyzed. As examples of selected LCC calculation methods, set chronologically from 1969, you can mention:

– the Kaufman method[5];
– the Harvey method[6];
– the Fabrycky and Blanchard method[7];

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1 G. Dębniewski, H. Pałach, W. Zakrzewski, *Mikroekonomia*, UWM Publisher, Olsztyn 2000.

2 M. Sierpińska, T. Jachna, *Ocena przedsiębiorstwa według standardów światowych*, PWN, Warsaw 1994.

3 Analysis of investment effectiveness of the acquisition project by PKP Cargo S.A. new electric multi-system locomotives for international freight services. Paper No. M-8/297/2012, Cracow University of Technology, Institute of Rail Vehicles, Cracow 2013; Feasibility study for the project of modernization of the EU07 series electric locomotive for international freight transport. Paper No. M-8/493/2015/P, Cracow University of Technology, Institute of Rail Vehicles, Cracow, November 2015.

4 H.P. Barringer, *A Life Cycle Cost Summary*, International Conference of Maintenance Societies, Perth, Australia 2003; H.P. Barringer, D.P. Weber, *Life Cycle Cost Tutorial*, Fifth International Conference on Process Plant Reliability, Houston, USA 1996; I. Dziaduch, *Modele szacowania kosztu cyklu życia: przegląd literatury*, Logistyka 2010, 2 (CD); P. Hokstad, K. Oien, J. Vatn, *Life Cycle Cost Analysis in Railway Systems*, SINTEF Safety and Reliability, Norway 1998; D.G. Woodward, *Life cycle costing – theory, information acquisition and application*, International Journal of Project Management 1997, 6, p. 335–344.

5 R.J. Kaufmann, *Life Cycle Costing: Decision Making Tool For Capital Equipment Acquisition*, Journal of Purchasing 1969, August.

6 G. Harvey, *Life-cycle costing: a review of the technique*, Management Accounting 1976, October.

7 W.J. Fabrycky, B.S. Blanchard, *Life Cycle Cost and Economic Analysis*, Prentice Hall, Englewood Cliffs, New Jersey 1991.

– the D.G. Woodward method[8];
– the Life Cycle Environmental Cost Analysis (LCECA) method[9];
– the method according to PN-EN 60300-3-3:2017-07[10].

On the basis of general guidelines included in professional literature and international standards, an attempt was made to develop a comprehensive method for identifying and assessing the lifecycle cost for rail transport means. The methodological basis of the algorithm is compliant with the requirements of the PN-EN 60300-3-312 standard. This method includes a total of six stages, which are described in points 2.1 ÷ 2.6 and can be used both for LCC assessment of a specific vehicle and for a comparative analysis of many variants related to their purchase or modernization.

2.1. Development of assumptions, input data and the purpose of the analysis

Stage 1 in the proposed method involves the development of assumptions, the collection of source materials, the preparation of input data and the definition of objectives to be provided by the analysis. In the case of a variant analysis consisting in the comparison of various possible solutions, the stage includes the detailed identification of the variants to be analyzed. The input data concerns:
– identification of technical parameters of the vehicle;
– identification of the conditions, time and intensity of the vehicle operation, e.g. average daily working time, mileage and transport performance performed during the year;
– analysis of requirements resulting from the vehicle maintenance documentation, e.g.: measures of the interval between preventive services, scope of inspection and periodical repairs;
– assumptions regarding the discount rate being the basis for calculations and others.

As examples of LCC analysis aims, you can indicate[11]:
– comparative assessment of total costs or operating costs of various types of new vehicles offered by suppliers and selection of the optimal variant from the point of view of the carrier's needs;
– comparative assessment of various variants of vehicle modernization (various assemblies and components used for modernization: combustion engine, steering, braking system, ergonomics solutions for the driver's cab, etc.);
– identification of dominant costs having the greatest impact on LCC in order to direct development work.

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[8] D.G. Woodward, *Life Cycle Cost…*
[9] S.K. Durairaj, S.K. Ong, A.Y. Nee, R.B.H. Tan, *Evaluation of Life Cycle Cost Analysis Methodologies*, Corporate Environmental Strategy 2002, 1, p. 30–39.
[10] PN-EN 60300-3-3:2017-07 – Reliability management. Application Guide – Estimating the Life Cycle Cost.
[11] M. Szkoda, *Evaluation of economic efficiency of rail vehicles with the use of the LCC analysis* [in:] *Problems of Maintenance of Sustainable Technological Systems*, PAN, Warsaw 2012, p. 234–248.

2.2. RAMS analysis

Stage 2 is to perform a reliability analysis of RAMS (Reliability, Availability, Maintainability, Safety) for all identified variants. A detailed description of the RAMS analysis and indicators allowing a quantitative description of reliability for railway transport means is presented in PN-EN 50126-1:2018-02. Railway applications – Specification and demonstration of reliability, availability, maintenance compliance and security (RAMS) – Part 1: Process general RAMS. According to the requirements of the standard, the assessment of the reliability of rail transport means should be an integral part of the LCC calculation process. The choice of reliability indicators depends on the level of detail and the purpose of the analysis. As a basic set of indicators applicable to rail transport means[12]:

– mean number of failure in a given operation period MNF [failures/period];
– mean time between failures MTBF [hours];
– technical availability A;
– mean time to repair MTTR [hours].

In the proposed method, vehicle reliability characterized by RAMS indicators is the basis for building the cost model (Figure 1).

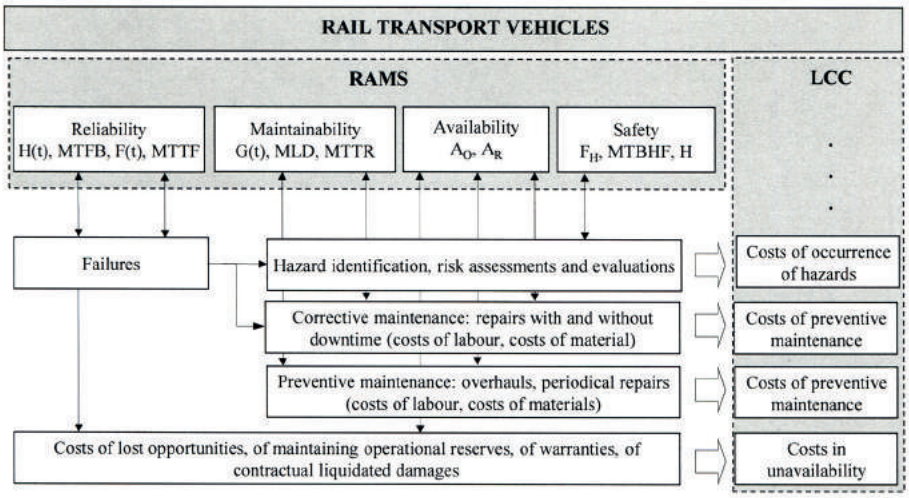

Figure 1. Relation between RAMS and LCC of railway transport means
Source: own elaboration based on: PN-EN 60300-3-3:2017-07 – Reliability management. Application Guide – Estimating the Life Cycle Cost

The results of the conducted analyzes prove that the reliability characteristics of rail vehicles have a significant impact on the costs of use and maintenance[13].

[12] M. Szkoda, *Analiza niezawodności lokomotywy spalinowej serii SM48*, Logistics 2012, 3, p. 2203–2211.

[13] Life cycle cost analysis (LCC) of the ST48 series 15D/A diesel locomotive. Paper No. M-8/494/2015/P, Cracow University of Technology, Instute of Rail Vehicles, Cracow, July 2015; Assessment of the efficiency of modernization of SM42 series locomotives operated by KOLPREM Sp. z o.o. based on the life cycle cost analysis (LCC). Paper No. M-8/648/2015/P, Cracow University of Technology, Institute of Rail

In most studies regarding this issue, losses caused by the unreliability of the vehicle are treated as a determinate amount, specific costs of switching off the vehicle or costs of repairs. In fact, there are also losses associated with the direct effect of disability, resulting, for example, from the loss of benefits arising during the period of the vehicle's unserviceability, the cost of contractual penalties, costs associated with the loss of the company's reputation and prestige or loss of customers. In the monograph[14], the author presented calculation formulas for selected categories of costs depending on the characteristics of RAMS, which depend primarily on the availability of a reliability database.

2.3. Development of the LCC cost model

The LCC cost model created in stage 3 consists in distinguishing the features of the vehicle and transforming them into numbers relating to costs. In order to get a realistic model it is recommended to reflect the characteristics of the analyzed variant, including expected usage scenarios and maintenance strategies.

The model should be simple enough to be easy to interpret and allow for future use, upgrades and modifications. It should be defined in such a way that allows the assessment of specific LCC elements independently of the others. The development of the cost model may include:

– defining the Costs Breakdown Structure (CBS);
– defining the product breakdown structure (PBS);
– defining of cost elements.

One of the above-mentioned tasks in the construction of the LCC model is defining the cost division structure. It involves the decomposition of cost categories at the highest level, i.e. purchase costs, operating costs and liquidation costs for component costs[15]. According to the PN-EN 60300-3-3:2017-07 standard, each cost category should be divided until the lowest level of the so-called cost element. The cost element is a value that cannot be expressed as the sum of other costs. It is defined by means of mathematical formulas containing functions, constant values and indicators, e.g.: failure intensity, mean time between failures, labor consumption of current repairs and others. The concept of defining cost elements in multidimensional space was proposed for the first time in the program of the Ministry of Defense of the United States Integrated Logistics Support (DOD Directive 4100.35 from 1968) and in PN-EN 60300-3-3 from 2017.

The structure of the vehicle division consists in the decomposition of the vehicle into systems (subsystems) and components. It is used when the purpose of the analysis is a detailed assessment of costs not only at the level of the vehicle as a system,

Vehicles, Cracow, August 2015; Strategy of renewal of the locomotive park in the enterprise of PKP LHS Sp. z o. o. Stage 1: Modernization of ST44 series locomotives. Paper No. M-8/599/2007, Cracow University of Technology, Institute of Rail Vehicles, Cracow, 2007; Technical and economic study of the renewal of the traction vehicle park operated by PKP CARGO S.A. Paper No. M-8/631/2006, Cracow University of Technology, Institute of Rail Vehicles, Cracow, 2006–2007; Feasibility study for the project of modernization of the EU07 series electric locomotive…

[14] M. Szkoda, *Kształtowanie potencjału przewozowego przedsiębiorstw transportu kolejowego*, Monograph, Cracow University of Technology Publisher, Cracow 2017.

[15] PN-EN 60300-3-3 – Reliability management…

but also at the level of its elements. The detailed structure of the division of the rail vehicle that can be used in the LCC analysis is described in PN-EN 15380-5:2014-Railway. Classification system for rail vehicles. Part 5: System breakdown structure (Railway applications. Classification system for railway vehicles).

2.4. Analysis of the LCC model

The analysis of the cost model carried out under Stage 4 includes:
- calculation of all cost elements included in the model;
- calculation of total costs within the assumed time horizon, calculation of individual cost categories on an annual basis (in the case of variant analysis for all analyzed variants);
- identification of dominant costs in the LCC.

At this stage, it is also proposed to assess the inaccuracy of the results obtained using a sensitivity analysis or a probabilistic risk analysis. In the first place, the assessment of inaccuracies should include input variables affecting the dominant costs. The description of the inaccuracy assessment related to the variables used as input data for the analysis and the results obtained are presented in the paper[16].

2.5. Review and presentation of results

Stage 5 in the proposed procedure is a review and presentation of results. The review, which is aimed at confirming the correctness of results and applications, includes:
- the purpose and scope of the analysis: were they properly formulated and interpreted;
- the assumptions made during the analysis process: making sure that they are justified;
- the cost model: make sure that it is suitable for the purpose of the analysis and that all necessary cost elements are included.

If it was found that the created model contains any errors, then it is necessary to improve and complete the initial concept. The presentation of the results should contain a clear summary of the results obtained from the calculation for all analyzed variants. In order to select the variant with the highest effectiveness, the presentation should include: comparison of LCC costs, LCC distribution in the assumed time horizon, LCC structure, LCC dominant costs and unit costs expressed as a function of working time, mileage, etc. The decision criterion in relative assessment, when the comparative analysis several variants takes place, is minimizing the LCC value. The variant characterized by the lowest LCC value is considered the most effective.

[16] M. Szkoda, *Niepewność i ryzyko w analizie LCC kolejowych środków transportu*, Logistics 2015, 4, p. 8373–8379.

2.6. Verification of LCC analysis

Verification of LCC analysis results is the last very important stage that requires continuous monitoring, collection and analysis of actual operational data. The railway transport operation phase covers more than 90% of the duration of the entire lifecycle and is a basic source of information. On the basis of the information obtained, an assessment of the accuracy of the calculations made is made. The implementation of the objectives and benefits of the LCC analysis should be monitored from the moment the new or modernized vehicle is put into operation. On the basis of actual data, the RAMS indicators used in the analysis are verified as well as the correctness and accuracy of the cost statements made. Too large discrepancies going beyond the boundaries set out in the contract between the manufacturer, the modernization contractor and the railway carrier form the basis for possible claims, contractual penalties as well as the necessary construction, operational or organizational changes to meet the carrier's expectations.

Conclusions

The LCC analysis, as a tool for assessing alternative options, is in many countries an instrument required legally for the implementation of new investments, making tenders for the provision of services or construction of technical facilities – usually with a high initial value and long-term durability. It concerns railway means of transport. The decision to purchase or modernize rail transport means is influenced not only by the initial cost associated with investment expenditures for the purchase or modernization, but also the costs of use and maintenance throughout the life cycle. The LCC analysis also makes it possible to take into account one of the most important characteristics of railway transport means, that is reliability, characterized by the characteristics of RAMS (Reliability, Availability, Maintainability, Safety).

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Sierpińska M., Jachna T., *Ocena przedsiębiorstwa według standardów światowych*, PWN, Warsaw 1994.
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APPLICATION OF SELECTED METHODS FOR EFFECTIVENESS EVALUATION ON THE EXAMPLE OF MODERNIZATION OF ST44 DIESEL LOCOMOTIVE

Abstract

The paper presents the effectiveness evaluation of modernization of the ST44 diesel locomotive based on the analysis of the Life Cycle Cost Analysis and the Cost-Benefit Analysis. The analysis was aimed at identifying measurable economic effects obtained thanks to the modernization of the locomotive in the 25-year period of operation.

Keywords: effectiveness assessment, LCC analysis, cost-benefit analysis, rail transport

Introduction

Among the undertakings aimed at increasing the efficiency of railway transport, activities in the scope of reducing the costs of exploitation and maintenance of traction vehicles play an important role. A way to achieve this goal is the modernization of diesel locomotives, taking into account the conditions of exhaust and noise emissions. The modernization of a railway vehicle should be understood as modification works that change the purpose of the vehicle or improve its overall technical performance, in particular: change of traction characteristics, maximum speed, power, ability to power in different systems[1]. Most often rolling stock mod-

[1] Announcement of the Minister of Infrastructure and Construction of 27 January 2016. regarding the publication of a uniform text of the Regulation of the Minister of Infrastructure on general technical conditions for the operation of railway vehicles (Journal of Laws of 2016, item 226, as amended).

ernization is made for economic or technical reasons. The following are the main goals of modernizing railway transport means[2]:
– improvement of operational efficiency through reduction of energy or fuel consumption;
– increase in the safety of use;
– increasing inter-repairs;
– increasing technical readiness;
– adjusting technical parameters to the requirements of international regulations;
– reducing negative impact on the natural environment in the field of noise, vibrations and emission of toxic components to the atmosphere;
– improving the working conditions of the driver (ergonomics);
– increase of service comfort indicators.

The subject of the article is the evaluation of the effectiveness of modernization of the ST44 series diesel locomotive. This assessment was the subject of research carried out at the Institute of Rail Vehicles of the Cracow University of Technology[3]. In order to carry out the effectiveness assessment, the life-cycle cost analysis and cost-benefit analysis were applied.

1. Variants to be analyzed

Two variants were adopted in the analysis of the modernization efficiency of the ST44 locomotive:
– ST44 (14D40): an unmodified ST44 locomotive with a 14D40 engine;
– ST44 (GE): a modernized ST44 locomotive based on the integrated General Electric power unit with 2163 kW (2900 hp).

These variants have been described in detail in scientific studies[4] prepared by the Institute of Rail Vehicles of the Cracow University of Technology on behalf of a railway carrier in the years 2007–2017. The analyzed variant of the ST44 locomotive modernization concerns the concept proposed by NEWAG S.A., made on the basis of General Electric technology. Modernization in this solution involves the use of an integrated power unit (the so-called "Power Skid"), which includes: an internal combustion engine, generator, air compressor, cooling system and control system. The chassis and bogies are built on the basis of the construction of an old locomotive. The scope of modernization works also includes the modernization of the original traction motors, which are refined on the basis of GE materials

[2] A. Tułecki, *Ekonomiczno-techniczne aspekty odnowy parku spalinowych pojazdów trakcyjnych*, Czasopismo Techniczne 2005, 3-M.

[3] Strategy of renewal of the locomotive park in the enterprise of PKP LHS Sp. z o. o. Paper No. M8/599/2007, Cracow University of Technology, Institute of Rail Vehicles, November 2007; Announcement of the Minister of Infrastructure and Construction of 27 January 2016, regarding the publication of a uniform text of the Regulation of the Minister of Infrastructure on general technical conditions for the operation of railway vehicles (Journal of Laws of 2016, item 226); Evaluation of the modernization efficiency of ST44 series locomotives based on current operational data. Paper No. M-8/14/2010/6, Cracow University of Technology Institute of Rail Vehicles, Krakow, May 2010.

[4] *Ibidem*.

and technology. The proposed type of modernization relies on replacing all the most important devices with the locomotive control system.

a) b)

Figure 1. View of the ST44 series locomotive: a) before modernization, b) after modernization
Source: NEWAG S.A.

The propulsion system is a 12-cylinder four-stroke IC engine with the designation 7FDL12 EFI, equipped with electronic fuel injection. The modernized locomotive is equipped with two modified driver's cabins equipped with an altered control panel and a diagnostic information display. The locomotive was equipped with the new "Oerlikon" braking system. As a result of the modernization, the first locomotive was built on the Polish and European market, built on the basis of the integrated General Electric power unit, meeting current emission standards.

2. Life cycle cost analysis

In the first stage of the assessment of the modernization efficiency of the ST44 locomotive, the life cycle cost analysis (LCC analysis) was used. The analysis was carried out using a 6-step procedure, described in detail in the work[5], taking into account the requirements of the international standard PN-EN 60300-3-3 Reliability management. Application Guide – Estimating the Life Cycle Cost. As a measure of effectiveness, the lifecycle cost (LCC) calculated in the 25-year operational period of the locomotive was adopted.

2.1. Initial assumptions

The assumption was made that the analysis is of a comparative nature, consisting in comparing the economic effects obtained in locomotive exploitation before modernization with the effects obtained after its modernization. In the first stage

[5] M. Szkoda, *Kształtowanie potencjału przewozowego przedsiębiorstw transportu kolejowego*, Monograph, Cracow University of Technology Publisher, Cracow 2017.

of the analysis, a set of input data was developed for both the unmodified and modernized locomotive. In the case of an unmodified locomotive, it was necessary to determine:
– load distribution of the drive system for the actual operating conditions;
– actual fuel and engine oil consumption;
– working time, mileage, transport performance during the year;
– periodicity, labor consumption and costs of preventive maintenance resulting from the maintenance cycle;
– reliability indicators RAMS (Reliability, Availability, Maintainability, Safety).

Based on the operational data of the ST44 locomotive park operated by the railway carrier, the load schedule of the internal combustion engine was determined and the following operational indicators were determined:
– average annual mileage of the locomotive: 118 000.0 [km/year];
– average working time of the locomotive: 5200.0 [hour/hour];
– average transport work: 179 000.0 [thousand btkm/year].

2.2. The LCC model

Due to the comparative nature of the analysis, a common cost model was developed for the adopted variants, in which the LCC was expressed in the following formula:

$$LCC = \sum_{t=1}^{T}\left[(KN_t + KE_t)\cdot\frac{1}{(1+i)^t}\right] = \sum_{t=1}^{T}\left[(KN_t + KUP_t + KUB_t + KBG_t + KZP_t + KZO_t)\cdot\frac{1}{(1+i)^t}\right],$$

where:
KN_t – acquisition costs in year t,
KE_t – operating costs in year t,
KUP_t – costs of preventive maintenance in year t,
KUB_t – corrective maintenance costs in year t,
KBG_t – costs of unavailability in year t,
KZP_t – fuel consumption costs in year t,
KZO_t – costs of engine oil consumption in year t,
i – discount rate,
t – another year in the cycle of the locomotive's existence,
T – assumed operating time of the locomotive.

The acquisition costs of the KN in the base variant (variant ST44 14D40) constitute the maintenance costs of P5 (main repair). For the modernized ST44 locomotive (ST44 GE variant), the acquisition costs are total expenditures for modernization, taking into account, among others: costs of documentation, costs of commissioning, purchase and delivery costs of the internal combustion engine, costs of necessary components and elements, and labor costs. It was assumed that the modernization of the locomotive will be carried out as part of repairing the maintenance level P5. The KE operating costs are costs related to the operation of the locomotive, i.e. maintenance and use. They are costs of fuel consumption, engine oil, corrective maintenance, preventive maintenance and others.

In the applied model, 12 cost elements were defined using 28 parameters and functions. The cost elements were estimated using the engineering method of cost estimation[6]. The LCC analysis was performed on undiscounted and discounted costs (discount rate $i = 5\%$ in line with EU recommendations for the assessment of investment projects in rail transport).

One of the cost elements was the corrective maintenance costs (KUB) related to the repair of the current locomotive. These costs include labor costs (KUBR) as well as costs of materials and spare parts (KUBM). The corrective maintenance costs on an annual basis were expressed in the following formula:

$$KUB_t = KUBP_t + KUBM_t = MNF \cdot [(MMH_B \cdot CPH_B) + ACM_B],$$

where:
MMH_B – average labor consumption of current repair,
CPH_B – cost of man-hour for the current repair,
ACM_B – cost of materials used in the current repair,
MNF – mean number of locomotive failures in the year of operation:

$$MNF = \frac{TZ}{MTBF},$$

where:
TZ – average working time of a locomotive in a calendar year in [hour/year],
$MTBF$ – mean time between failures in [hours].

Preventive maintenance costs (KUP) are expenditures for repairs and periodic inspections resulting from the maintenance plan for the locomotive.

The costs of unavailability (KBG) are the sum of costs resulting from the locomotive being in a condition that makes it impossible to perform the tasks planned for implementation. The costs of unavailability include, for example: costs of contractual penalties, costs of guarantees, costs of lost opportunities and others. In the calculation formula for KBG, the technical readiness index designated as part of the reliability analysis is used.

The costs of diesel oil consumption (KZP) and engine oil (KZO) were calculated on the basis of actual operational data collected by the carrier and using the characteristics of the new 7FDL12 EFI type internal combustion engine. The advanced method used in the LCC analysis to calculate the fuel consumption of diesel locomotives is the use of a mathematical model of operating conditions of the power unit: engine – generator together with a simulation model, allowing to map the actual operating conditions of the locomotive. This approach is presented in the paper[7].

2.3. The analysis of the cost model and final results

The analysis of life cycle costs according to the developed model showed that the proposed variant of modernization of the ST44 locomotive based

[6] PN-EN 60300-3-3:2017-07 – Reliability management. Application Guide – Estimating the Life Cycle Cost.

[7] M. Babeł, M. Szkoda, *Diesel locomotive efficiency and reliability improvement as a result of power unit load control system modernization*, Eksploatacja i Niezawodność – Maintenance and Reliability 2016, 18(1), p. 38–49.

on the integrated drive unit of General Electric is economically justified. The calculations performed using the CATLOC software show that the modernization of the locomotive provides very high savings in LCC costs – nearly PLN 11.3 million, i.e. 19.8% less compared to an unmodified locomotive. The comparison of total costs in the 25-year period after modernization for the analyzed variants is presented in Figure 2a. Significant savings are obtained in the operating costs of the modernized locomotive. These costs are 27.2% lower compared to an unmodified locomotive (Figure 2b).

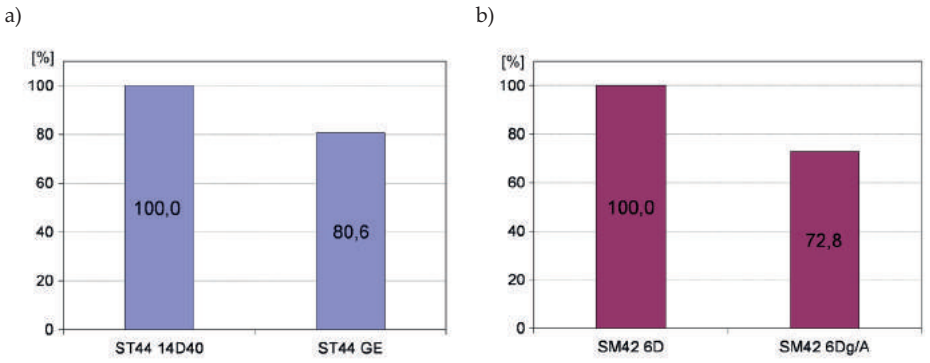

Figure 2. Comparison of the costs of the analyzed variants: a) LCC total costs, b) KE costs of exploitation
Source: own elaboration

For the unmodified ST44 locomotive, the dominant costs are fuel consumption costs (KZP) 72.1% and costs of unavailability (KBG) 12.0%. Preventative maintenance costs (KUP) constitute 8.9% of total costs (Figure 3a).

For the modernized ST44 GE locomotive, a significant reduction in the costs generated in the life cycle was obtained thanks to increased reliability, readiness and availability of spare parts. This results in a significant reduction of expenditures for corrective maintenance and lower costs of preventive maintenance of the vehicle (inspections, periodic repairs). The costs of preventive maintenance (KUP) and corrective maintenance (KUB) of the modernized locomotive account for 9.4% of total costs.

The largest share in LCC is fuel costs (KZP) 69.5% (Figure 3b).

The largest savings compared to the non-modernized locomotive concern the costs of diesel oil consumption and engine oil costs. The calculations, confirmed by supervised operation, showed that fuel savings amount to 22.2% on average and 62.3% in engine oil consumption. Considering the probability of fuel price increases, this is of great importance in long-term planning.

The analysis showed that the modernization of the ST44 diesel locomotive based on the integrated General Electric power unit provides significant savings in operating costs compared to the unmodified locomotive. Table 1 presents the average

level of savings in annual terms for selected categories of costs of the modernized ST44 locomotive.

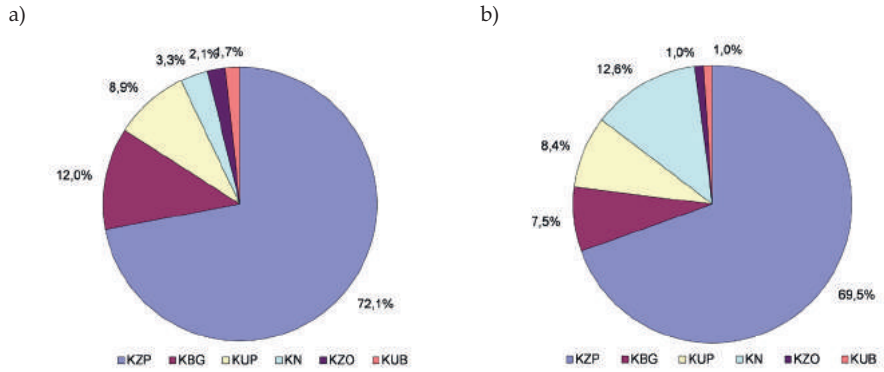

Figure 3. Structure of LCC costs of the analyzed variants: a) variant ST44 14D40, b) variant ST44 GE
KZP – fuel consumption costs, KUP – preventive maintenance costs, KN – purchase costs, KUB – corrective maintenance costs, KBG – unavailability costs, KZO – motor oil consumption costs
Source: own elaboration

Table 1. Average annual savings for the ST44 GE locomotive

Cost category		KUP	KUB	KZP	KZO	KBG
Savings	%	22.9	50.8	22.2	62.3	50.0
	PLN/year	58 899.3	25 263.7	456 618.6	37 861.4	174 762.0

Source: own elaboration

4. The cost-benefit analysis

In the next stage of the assessment of the efficiency of the modernization of the ST44 locomotive, a cost-benefit analysis was carried out. The cost-benefit analysis is simply a reduction of the assumed future costs and benefits from the modernization of the locomotive to current values, taking into account the change in the value of money over time. The purpose of the analysis is to provide information on whether the modernization of the locomotive provides appropriate benefits adequate to the costs of modernization.

The analysis was carried out in accordance with the recommendations of UNIDO – the United Nations Organization for Industrial Development. The analysis includes all data developed for the needs of LCC calculations and was supplemented with additional assumptions, such as investment financing costs, depreciation costs, tax charges, operating revenues and other. As a result of the analysis using the UNIDO Comfar III Expert software, the following values of indicators characterizing the efficiency level of the locomotive modernization were determined:

– updated Net Present Value, NPV = PLN 3 924 413.3;
– Internal Rate of Return, IRR = 14.62%;
– Payback Period, PP = 7.4 years;
– Discounted Payback Period, PP = 9.3 years.

Based on the calculated indicators of the cost-benefit analysis, it was found that the analyzed version of the modernization of the ST44 locomotive shows economic justification, which confirms the correctness of its choice based on the LCC criterion. In addition, a sensitivity analysis was carried out for the analyzed option, aimed at determining the so-called limit expenditures, i.e. the maximum expenditure on the modernization of the locomotive. Taking into account all the assumptions from the LCC analysis and the requirements regarding the method of financing the project, the calculated safety margin due to capital expenditures is 86.5%. With such an increase in the estimated expenditures for modernization, the economic effects obtained in the 25-year period of locomotive exploitation are comparable to the effects obtained for the locomotive before modernization.

Conclusions

The purpose of modernizing the ST44 diesel locomotive was to adapt it to the modern requirements of functional properties. The main areas of reconstruction and modernization concerned: a power unit with the engine with a limited level of exhaust emissions, microprocessor control of the engine-generator unit, improved cab ergonomics and driver's work stations, economic drive of machines and auxiliary equipment and improvement of braking system components.

The level of error committed in the analysis of the efficiency of locomotive modernization depends on the stage of its implementation and the richness of the database available. The input database for the analysis and assessment of the modernization efficiency of the ST44 locomotive is based on the current costs of modernization, preventive and corrective maintenance costs as well as diesel and motor oil prices. The analysis also uses actual data on fuel consumption by non-modernized locomotives, which are important in the calculation of LCC. The conducted efficiency assessment showed that the modernization of the ST44 diesel locomotive provides significant savings in operating costs in relation to the non-modernized locomotive. In the period of 25 years of use, the savings may amount to approximately PLN 11.3 million, i.e. 19.4% LCC for one locomotive. The comprehensive, complex assessment of effectiveness in the concept and design phase was the basis for the railway undertaking's decision to modernize the first batch of 30 ST44 locomotives.

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BARRIERS FOR THE DEVELOPMENT OF TRANSPORT OF TRAILERS AND TRUCKS BY RAIL IN POLAND

Abstract

The idea of developing sustainable transport in Europe promotes ecological forms of transport. One of such solutions is the transport of trailers and trucks in rail traffic. The development of this form of intermodal transport encounters many barriers of legal and organizational nature, cost and resulting from time of service provision. Increasing the competitiveness of intermodal transport, in particular the transport of trailers and trucks in Poland, may take place through a series of activities of an investment and administrative nature by the infrastructure manager of PKP PLK S.A. and of a legal nature by the authorities of the country.

Keywords: intermodal transport, sustainable mobility, barriers of railway development, road and railway transport in Poland

Introduction

The development of transport and the intensification of transport processes, in particular road transport, lead to negative extern effects in the form of degradation of the natural environment, noise, air pollution and congestion. In the transport and economic policies of developed countries as well as integration groups, the idea of sustainable development of transport gains in importance. The idea of sustainable transport assumes such a development of transport that will satisfy the current transport needs and mobility without compromising the ability of future generations to meet these needs[1]. The OECD[2] has adopted the definition of a sustainable transport system as such that does not threaten public health and the ecosystem

[1] W.R. Black, *Sustainable Transportation: A U.S. Perspective*, Journal of Transport Geography 2006, 4, p. 151–159.

[2] *OECD Guidelines towards Environmentally Sustainable Transport*, OECD, Paris 2002, p. 16.

and meets the need for access to transport, compatible with the use of renewable energy below the regeneration threshold, and the use of non-renewable energy resources below the development threshold of renewable substitutes. One of the objectives of the European Commission is to reduce the negative effects associated with mobility. This means, above all, promoting co-modality, i.e. the optimal combination of different modes of transport within the same transport chain. Much more technical innovation and the shift to the least polluting and most energy-efficient means of transport will contribute to more sustainable mobility[3]. One of the transport modes promoting co-modality and limiting the external costs of transport is the transport of trailers and trucks by rail.

The purpose of this article is to identify barriers to the development of transport of trailers and trucks by rail and to propose recommendations reducing restrictions and allowing to strengthen the competitiveness of intermodal transport in Poland.

1. Sustainable transport in selected EU documents

Intermodal transport is understood as the carriage of freight in one and the same vehicle or cargo unit (without transshipment) using various modes of transport[4]. Due to the type of cargo units used, it can be divided into the transport of containers, trailers, swap bodies, trucks and special containers[5]. The subject of interest in this study is the transport of trailers and trucks by rail.

Intermodal transport is one of the most important elements of the construction of a sustainable transport system and is an ecological alternative for the majority of road transport of freight. The role of intermodal/rail transport has been emphasized in the latest EU 2020 strategy of 2010[6] and in the most recent transport document, i.e. the White Paper of Transport from 2011[7].

One of the initiatives enshrined in the White Paper on road transport is the alignment of legislation (guaranteeing) that it facilitates the use of intermodal transport and the reduction of total energy consumption and emissions. Among the ten objectives to create a competitive and resource efficient transport system, the following was written: "By 2030, 30% of road freight over distances greater than 300 km should be transferred to other modes of transport, such as rail or water transport, and by 2050 this should more than 50% of this type of transport 'and' completing the fast European rail network by 2050. Three times increasing the existing high-speed rail network by 2030 and maintaining a dense railway network

[3] European Commision, Sustainable transport, https://ec.europa.eu/transport/themes/sustainable_en (access: 18.02.2018).

[4] Economic Commission for Europe, *Terminology on combined transport*, New York/Geneva 2001, http://www.unece.org/trans/wp24/documents /term.pdf (access: 20.02.2018).

[5] J. Neider, D. Marciniak-Neider, *Przewozy intermodalne w transporcie międzynarodowym*, WUG, Gdańsk 1992.

[6] *Europe 2020: A strategy for smart, sustainable and inclusive growth*, European Commision, Brussels, March 2010, COM(2010) 2020 final version, p. 11, 18.

[7] *The White Book – Plan utworzenia jednolitego europejskiego obszaru transportu – dążenie do osiągnięcia konkurencyjnego i zasobooszczędnego systemu transportu*, European Commision, Brussels, 28.03.2011, COM(2011) 144 final version.

in all member countries"[8]. The political objective of the undertaken and declared actions is to transform the EU transport system until 2050 in effective, consistent and functioning in accordance with the principles of sustainable development.

According to the European Union 2020 Strategy: A strategy for smart, sustainable and inclusive development, the focus on sustainable development undertaken by the entire group and individual countries belonging to it should be to support a more resource-efficient, more environmentally friendly and more competitive economy. At the EU level, the European Commission declared accelerating the implementation of strategic projects with high added value from Europe, aimed at unloading the largest overloads, above all on cross-border sections and intermodal nodes, and presenting legislative proposals on modernizing the transport sector and reducing its share in carbon emissions, which will contribute to increasing competitiveness.

2. Characteristics of road and rail transport in Poland

According to the Central Statistical Office (Poland) data for 2016, 1836.7 million tons of freight were transported by all modes of transport, and transport work in the amount of 385.7 billion ton-kilometers. Rail transport (excluding maneuvering work) accounted for 12.1% of the total transported mass of goods, with respectively 84.2% for road transport[9].

Table 1. Share of selected transport modes (in tons) in Poland in 2004–2016

Type of Transport	Year								
	2004	2006	2008	2010	2012	2013	2014	2015	2016
Rail	21.4	19.7	15.0	13.1	12.9	12.6	12.4	12.4	12.1
Road	79.2	75.2	80.9	83.1	83.4	84.1	84.1	83.5	84.2

Source: own elaboration based on: CSO data

Table 1 presents the change of the structure of freight transport by rail and roads between 2004 and 2016. It is possible to observe a systematic decrease in the share of rail transport in the total weight of transported goods, with the simultaneous increase in the share of mass transported by road. At least several reasons can be found for increasing the attractiveness of road transport at the expense of rail transport. Firstly, the development of the road network in Poland, especially the highways belonging to the European corridors. In the case of investments in railway infrastructure, works relate primarily to investments in the already existing railway network, which temporarily limits its capacity. This leads to a reduction in commercial speed and higher transport costs. Secondly, the road network is much better developed and has more transport accessibility. Road transport is less demanding in terms of specialized infrastructure (sidings, terminals, devices for unloading railway wagons) and access to it (railway network capacity, track

[8] *Ibidem*, p. 9.

[9] *Transport. Wyniki działalności w 2016 roku*, Central Statistical Office, Warsaw 2017, p. 47–48.

closures, lack of electrification of part of the railway network). Thirdly, the departure from the energy policy, which was primarily transported by rail. While still in 2004, 152 000 tons of coal and briquettes were transported by rail and in 2016, respectively, 89 600 tones. The share of coal in the total weight of goods transported by rail decreased from 50.7% in 2004 to below 42% from 2009[10]. In 2004, 282.9 million tons were transported by train, in 2016 222.5 million tons, which was a decrease of 21.3%. In the case of road transport, in the same period, the transported weight increased by 61.6% from 956.9 million tons to 1546.6 million tons. The volume expressed in ton-kilometers in 2016 constituted 14.7% of the total transported weight in the transport of the European Union (EU 28), which placed Poland in the second position (behind Germany). Poland in international transport, with a share of over 25%, was the European leader ahead of Spain and Germany[11].

After 2004, investments in the area of transport infrastructure supported by European funds focused to the greatest extent on road infrastructure. Entry into the Schengen area and the systematically improving condition of road infrastructure and relatively low labor costs have become an opportunity for Polish entrepreneurs. Since the beginning of the 21st century, except for 2009, the value of foreign trade has been growing in Poland, which has its impact on the demand for transport work. In addition to the increasing road transport work, the number of registered lorries also systematically increased, as shown in Table 2.

During the 12 years between 2004 and 2016 almost 1 million trucks arrived in Poland. Calculated per 1000 inhabitants, the ratio increased year-on-year reaching the value from 59 in 2004 to 83 in 2016. The number of vehicles with a load capacity of over 1.5 tons was also systematically growing, with the percentage of this type of vehicles in relation to all registered lorries after 2008 the year was shrinking. A decrease in the percentage of vehicles up to 5 years old can also be observed.

Table 2. Characteristics of equipment for trucks and public roads in Poland in the years 2004–2016

Description	Year								
	2004	2006	2008	2010	2012	2013	2014	2015	2016
Trucks (in mln)	2.26	2.25	2.51	2.77	2.92	2.96	3.04	3.10	3.18
Per 1000 inhabitants	59	59	66	72	76	77	79	81	83
With a load capacity of over 1.5 tonnes (in %)	21.6	21.7	22.5	21.6	21.1	21.2	21.0	21.0	20.9
Vehicles up to 5 years old (in %)	35	22	17.7	17.2	16.1	14.6	13.8	12.7	11
Public roads in 1000 km	379.2	382.6	383.3	406.1	412.0	415.1	417.0	419.6	420.2
Trucks per 1 km of public roads	6.0	5.9	6.6	6.8	7.1	7.1	7.3	7.4	7.6

Source: own elaboration based on: CSO and Local Data Bank

In particular, the first years of Poland's membership in the European Union were characterized by a relatively high rate of "new" trucks. This percentage dropped

[10] Data based on the Central Statistical Office.

[11] *Transport. Wyniki działalności w 2016 roku…*, p. 53.

from 35% in 2004 to 11% in 2016. The reason for this phenomenon can be seen in the slow saturation of the Polish market in trucks.

Increasing the number of trucks on Polish roads went unevenly along with the growth of public roads. The number of kilometers of public roads between 2004 and 2016 increased by 10.8%. The ratio reflecting the number of trucks per 1 kilometer of public roads increased significantly, which in the corresponding period increased by 26.8%. This demonstrates the increasing burden of the transport network in Poland by trucks and thus with an increasing burden on the natural environment and inhabitants of Poland.

3. Transport of trailers and trucks by rail in Europe

In both Poland and throughout Europe, the most popular form of intermodal transport due to the transport unit is container transport. In Eurostat statistics, unlike the Office of Rail Transport statistics, container transport is included with the transport of interchangeable undercarriages. In this category in 2004 over 154 000 tons of goods were transported, while in 2016 over 234 500 tons of goods, which was an increase of 52%[12].

Much less popular forms of intermodal transport are transports of trailers and trucks. In the case of transport of trucks (with driver) by rail in 10 out of 28 examined EU countries either this form of intermodal transport did not occur at all, or values in some years were below 1000 tons, so they were not recorded in Eurostat. Transportation of trucks by rail is a relatively popular form of transport only in 5 European countries (Austria, Germany, Slovenia, Switzerland and Italy), mainly due to the terrain. Especially traveling by rail through tunnels in the Alps is saving time for car carriers. The declining popularity of truck transport by rail is systematically reduced by the amount of transported tons. While in 2010, a total of 26 105 thousand people were transported in 8 European countries. tons, in 2016 already with the participation of only 5 European countries transported tonnage fell to 18 047 thousand. tone.

Table 3. Transport of trailers by rail in selected European countries in thousand tons in the years 2004–2016

Country	Year								
	2004	2006	2008	2010	2012	2013	2014	2015	2016
Austria	1 309	1 252	2 020	3 436	3 486	6 752	7 065	7 999	8 637
Czech Republic	0	12	15	70	369	529	588	605	671
Denmark	967	638	718	1 115	1 191	1 357	1 092	1 128	1 306
Finlan	0	271	227	133	79	66	0	0	0
France	2 546	2 678	No data	1 837	1 078	1 029	1 313	1 803	1 749

[12] Based on Eurostat data. Statistical data is not complete. In 2004, there were no data for 3 countries, i.e. Bulgaria, Cyprus and Malta; in 2016, data was not available for 5 countries, i.e. Cyprus, Malta, Luxembourg, Croatia and Belgium.

Table 3. cont.

Country	Year								
	2004	2006	2008	2010	2012	2013	2014	2015	2016
Netherlands	162	81	14	No data	34	39	96	524	512
Germany	2 730	5 770	6 934	9 874	10 984	13 041	17 422	21 441	24 233
Norway	1 311	2 330	1 279	1 206	1 821	1 598	1 499	1 642	1 696
Poland	0	0	0	1	48	130	355	568	548
Switzerland	No data	No data	1 807	2 349	2 788	2 508	2 796	3 150	3 655
Sweden	1 543	2 260	2 610	3 945	3 719	4 123	4 086	4 339	4 162
Hungary	38	46	154	386	270	357	367	507	825
Italy	2 893	2 470	No data	4 443	9 554	5 752	10 299	10 579	11 018

Source: Eurostat

In the case of transport of trailers without a driver (Table 3), in 2004 12.25 million tons were transported (in EU 28), in 2016 54 million tons, which represented an increase of over 440%[13]. This proves the growing popularity of this type of transport throughout Europe. European leaders are Germany, who transported by rail in 2016 more than twice as many trailers than others in this ranking of Italians. The transport of trailers and trucks is popular in the Alpine countries. The countries of Central and Eastern Europe such as the Czech Republic, Poland and Hungary look promising.

The share of transport volume in intermodal transport in Poland is gradually increasing. In 2004 transport work carried out with the use of intermodal transport accounted for 1.87% of the total carriage work by rail. Before the economic crisis in 2008, it reached 4.29%, as a result of the crisis it dropped to 3.32% and since then it grew again to reach 8.77% in 2016[14]. In 2014 14 714 trailers were transported, which accounted for 2.1% of all units transported by intermodal transport, in 2015 the share increased to 3.7% (27 730 units) and in 2016 it decreased to 2.7% (25 817 units). The volume of transported trucks by rail in Poland was minor: 27 units in 2004 (0.004%), 775 in 2005 (0.1%) and 62 in 2016 (0.01%)[15].

4. Barriers and recommendations

The increasing tonnage transported in Poland by intermodal transport with the use of trailers results mainly from the implementation of international projects. The rail market in Poland is the second largest after the German market. In 2015 in Poland, 50.6 trillion ton-kilometers (tkm) were transported by rail, with

[13] Based on Eurostat data. In 2004, there were no data for Bulgaria, Cyprus and Malta. In 2016, there were no data for Cyprus, Malta, Belgium, Estonia, Ireland, Croatia and Luxembourg.

[14] *Analysis of railway intermodal transport in Poland*, Office of Rail Transport, Warsaw 2012, p. 14; Railway transport statistics, Office of Rail Transport annual reports, https://www.utk.gov.pl (access: 22.02.2018).

[15] *Analysis of railway intermodal transport in Poland*, Office of Rail Transport, Warsaw 2016, p. 4; *Przewozy intermodalne w 2016 roku. Podsumowanie prezesa UTK*, Department of Railway Market Regulation, Office of Rail Transport, Warsaw 2017, p. 4.

116.6 tkm in Germany and 34.3 tkm in France[16]. The size of the Polish railway market, the increasing number of trucks with limited transport infrastructure capacity, growing Polish trade and the geographical location of the country should constitute pressure and prerequisites for the development of intermodal transport, in particular the transport of trailers. The greater use of rail transport in Poland is connected with many barriers hampering the development potential of this type of transport. The most important barriers are presented in Table 4.

Table 4. Barriers to the development of intermodal transport in Poland

Barriers	Example
Legal and organizational	Relatively few periodic prohibitions of truck traffic on roads, access to the profession, the structure of enterprises in road transport, insufficiently developed point infrastructure
Resulting from the delivery's punctuality	Transshipment, lower commercial speed in rail transport, track closures
Cost	Costs of maneuvering and service in terminals, costs of access to infrastructure

Source: own elaboration

Barriers have been divided into three groups, with cost barriers being the most important group. Legal and organizational limitations and resulting from the punctuality of deliveries ultimately come down to higher transport costs and lower attractiveness to road transport.

The legal and organizational limitations in the development of transport of trailers and lorries by rail include insufficient legal solutions that would induce or encourage entrepreneurs to redirect part of the car transport to rail. While in some EU countries on weekends there is limited traffic in road transport, in Poland such rules apply only to selected days. However, the advantage of rail transport is the relatively lower demand for work than in road traffic, the regulations limit access to the train driver's objections. Both the costs of obtaining the right to drive a traction vehicle and the time of eligibility (about 2 years) constitute a barrier to access to this profession. Another barrier of a legal nature is the inclusion of intermodal transport for freight transport, which is associated with their lower priority when awarding the route. This is reflected in unfavorable scheduled driving times and stops on the trail. The insufficiently developed point infrastructure is an obstacle to the smooth performance of railway transport. Investments in the reconstruction of the railway network have meant that a large part of the so-called passing and parking tracks, which limits parking spaces on the route, among others in anticipation of a free slot in the terminal. Also, the structure of enterprises in road transport has an impact on the interest in moving some of the transports to rail. After 2007, the largest group (over 45%) were enterprises with 10 to 19 vehicles[17]. In 2016, 93% of all enterprises in commercial car transport had less than 50 trucks[18].

[16] *Transport in figures, Statistical Pocketbook 2016*, European Commission, Luxembourg 2017, p. 42.
[17] Enterprises in commercial car transport by number of owned trucks and tractor units.
[18] Data for the Central Statistical Office, Transport. Operating results for the years 2004–2016.

In the economic interest of small and medium-sized enterprises, it is not the resignation from own transport for rail transport.

The advantage of road transport is the provision of a service from the loading point to the unloading point. In the case of railways, there is still time necessary to perform railway maneuvers, reloading and other terminal services. Probably the most important limitation for the development of intermodal transport in Poland is low commercial speed. In 2014, the average speed for intermodal transport in international transport was at the level of 35 km/h[19], for national transport it was 28 km/h and for all freight transport it was 23 km/h[20]. Difficulties are numerous track closures resulting mainly from the modernization of transport infrastructure, which increase the cost of the service performed due to the extended driving time or the need to travel a particular part of the network.

The cost barrier in the development of intermodal transport is the relatively high cost of access to infrastructure compared to other EU countries. The same intermodal discount of 25% of the route costs is not enough to increase the attractiveness of intermodal transport in Poland. The Office of Rail Transport conducted a simulation in 2016, which shows that the railway can be more competitive only in cases where the majority of road transport is performed on paid sections. On routes where there is no toll system, the railway cannot compete with road transport when it comes to costs.

The recommendations refer to the infrastructure manager of PKP PLK S.A. and legislative power. In the case of the first addressee, intermodal transport should be treated equally with passenger transport in terms of access to routes and their development. When making investments, the infrastructure manager should pay more attention to stabling tracks and other point infrastructure. The costs of access to road and rail infrastructure should equalize the chances of both modes of transport. In addition, due to the limited capacity on the main trade routes (e.g. east-west axis) or between the largest centers, it would be advisable to build new railway lines running as parallel as possible to the present, divided into a freight and passenger route. The authorities of the country can point to the need to adjust the law to EU standards in the field of air quality. One of the possible ways is limiting access of trucks to cities and promoting the transport of road transport over a distance of more than 300 km per railways. Another solution would be to cover all public roads with a viaToll electronic payment or another form of leveling the chances of rail and road transport.

Conclusions

The European Union policy promotes sustainable transport, of which railway transport is an important part. After 2004, a constantly increasing number of trucks can be observed in Poland, which are increasingly burdened with road infrastructure and contribute to external costs incurred by the state budget. An alternative

[19] The transport of semi-trailers and lorries in Poland took place exclusively in international traffic.
[20] *Analysis of railway intermodal transport…*, p. 12.

to road transport is the transport of trailers and trucks by rail. Transport of trucks by rail in Europe is popular only in mountainous areas and its share in intermodal transport is declining. However, the transport of trailers is becoming more and more popular. Poland, due to its geographical location, relatively high demand for transport services and the railway network as well as the second largest railway market in Europe, has the potential to increase the share of transport of trailers in all rail transports. An obstacle in the development of this type of intermodal transport is primarily cost barriers, but also due to insufficient incentives and legal solutions that would promote rail transport. The low commercial speed in rail transport and the ongoing modernization of rail networks on a large scale limit the competitiveness of rail transport. In order to increase the role of intermodal transport in freight transport, legal changes would be recommended to level the chances of road and rail transport, especially in the area of fees for access to infrastructure. On the side of the rail infrastructure manager PKP PLK S.A. it would be recommended to include intermodal transport in the category of passenger transport and appropriate investments in point infrastructure to increase commercial speed and access to intermodal terminals.

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INNOVATIVE SOLUTIONS FOR INLAND WATERWAY TRANSPORT

Abstract

Contemporary changes in the global economy generate a significant increase in the demand for transport, which requires changes in transport, in accordance with the principles of sustainable development. Innovative solutions in transport, aimed at meeting modern expectations, concern various areas, most often these are technical, operational and logistics innovations. Road and air transport are seen as the most innovative transport branches.

The aim of the article is to show innovations implemented in inland waterway transport in those three areas. The article shows that in this mode of transport innovations are also implemented in accordance with the idea of sustainable development.

Keywords: inland waterway transport, innovations in transport, inland shipping

Introduction

Contemporary changes in the global economy generate a significant increase in the demand for transport. Globalization, tendencies to level disproportions in regional development, demographic changes and the associated increase in mobility result in an increase in demand for both passenger and cargo transport, whose satisfaction, in accordance with the principles of sustainable development, which requires radical changes in transport showing the implementation of innovative solutions in each branch and in the entire transport system. Road and air transport are seen as the most innovative transport modes nowadays. The aim of the article is to show that inland water transport is not inferior to others in search of solutions consistent with the idea of sustainable development.

1. Innovation in transport as a way to meet growing and changing transport needs

Socio-economic changes cause particular intensification of transport problems at the back of seaports and in the cities. 87% of transport work in the world is carried out by sea. Globalization, which entails an increase in trade turnover and consequently an increase in demand for cargo transport, thus results in an increase in turnover of sea ports (container ports even several times up to 2050[1]). Thus, there is a problem of the development of transport at the back of these ports, whose a solution is a serious challenge with the terrain restrictions and modern standards of sustainable development.

Another area of accumulation of transport problems are cities whose development makes it difficult to adapt the transport offer to the growing needs of residents in terms of both passenger and cargo transport. The predicted significant increase in the population living in European cities from 72.7% in 2010 to 82.2% in 2050 (including in Western European countries from 79.5% to 87.7%)[2] will necessitate the search for innovative solutions allowing to meet new challenges with existing terrain restrictions, energy constraints, policies to reduce pollutant emissions, in particular CO_2.

Innovative solutions in transport, aimed at meeting the presented expectations, relate to various areas, most often these are:

– technical;
– operational;
– logistics innovations[3].

Technical innovations regarding the vehicles construction, the materials they are made, the use of alternative fuels, the reduction of pollutant and noise emissions, safety improvements have long been implemented in various modes of transport. Currently, research on future solutions concerns mainly unmanned transport vehicles and environment-friendly drive solutions.

Among such concepts, currently at the design and testing stage, there is the hyperloop project, which was supposed to replace the high-speed railway, but it would also be well-suited for cargo transport and not only for long distances. This solution can also be used in supplying cities. The system is not new. Different versions of this idea were implemented earlier – from pneumatic mail in London in 1853, through various versions of pipeline cargo transport, including small containers in Hamburg[4].

The hyperloop concept was created on the initiative of the American entrepreneur Elon Muska. Scientists from various countries, including Poland, take part

[1] M. Quispel, *Medium and longterm perspectives in Inland Waterway Transport in the European Union*, NEA, Brussels, 5.07.2011.

[2] *World Urbanization Prospects: The 2011 Revision*, United Nations, Department of Economic and Social Affairs, Population Division, New York 2012.

[3] S.C. Consuegra, *Thesis for the degree of Master of Science in Maritime Technology, in the Specialisation of Shipping Management. The analysis and adoption of environmental innovations in inlandwaterway transport*, University of Technology Delft, 4.05.2016.

[4] See more: A. Gojlik-Wiśniewska, *Wykorzystanie transportu podziemnego w dystrybucji towarów*, Logistics 2011, 2.

in research on new technology. Muska's idea is that in a thin-walled tube with a diameter of several meters, placed on supports about a dozen meters above the ground, six-seat capsules are to travel at the speed of up to 1200 km/h (Figure 1).

In the tunnel, the pressure is to be lowered to approximately 1 atmospheric percent. Capsules will move on a magnetic cushion, reaching speeds higher than those of modern passenger airplanes. The speed of sound propagation is a barrier for both of these means of transport[5].

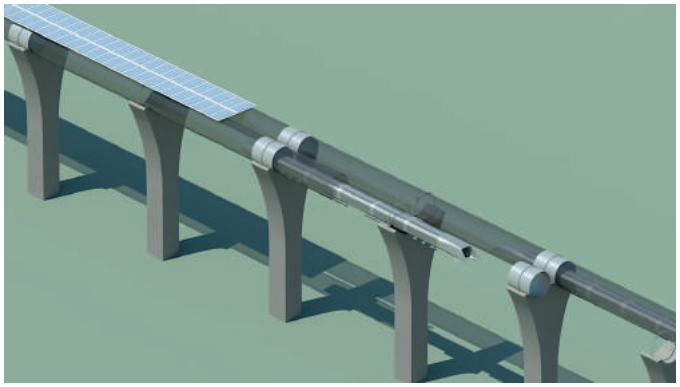

Figure 1. Hyperloop capsule in a pipeline with attached solar panels
Source: K. Urbański, *Hyperloop – railway for the future*, http://www.forbes.pl/hyperloop-szybka-kolej-nadchodzi-rewolucja,artykuly,204963,1,1.html (access: 26.03.2017)

The advantage of the hyperloop will be:
- low cost (according to hyperloop calculations on the San-Francisco – Los Angeles route, it would cost 10 times less than the passenger railway, traveling at a speed of 350 km/h and the ticket would cost $20);
- shorter transport time (this route would be travelled within half an hour);
- the possibility of building terminals in the city center;
- using renewable energy for the drive – the capsules (passenger cabins) are to be moved thanks to the use of electricity supplied by solar panels located along the entire route;
- no vibrations and noises in the cabin.

In Poland, there is a Hyper Poland University Team, which includes 25 engineers from the Warsaw University of Technology and the Wrocław University of Technology who are trying to develop a hyperloop solution for Polish conditions. The capsule according to the design of Polish scientists resembles modern high-speed trains (Figure 2). It is powered by electric motors and can move both on wheels and float with magnetic levitation depending on the current speed[6]. The design speed is approximately 430 km/h, while the maximum is 1200 km/h. The construction will be very light and at the same time very durable. For safety

[5] K. Urbański, *Hyperloop – railway for the future*, http://www.forbes.pl/hyperloop-szybka-kolej-nadchodzi--rewolucja,artykuly,204963,1,1.html (access: 26.03.2017).

[6] Spacex Hyperloop Pod Competition II, http://www.hyperpoland.com/news.html#news-1 (access: 20.04.2017).

reasons, it will be equipped with two independent braking systems. In addition, the electronic system will monitor the vehicle while driving and, if necessary, automatically initiate emergency safety procedures[7].

Figure 2. The project of the Polish hyperloop
Source: Hyper Poland materials, http://www.hyperpoland.com/news.html (access: 20.04.2017)

The location of the construction of the prototype currently under consideration is the Warsaw-Wrocław route, which the new means of transport would travel in less than 20 minutes. This route is among 35 potential routes selected in the Hyperloop One Global Challenge. The company intends to invest in building the prototype in the best location. Perhaps this technology, cheaper than traditional rail and providing transport in a much shorter time, will avoid the development of high-speed rail in Poland.

Another future project concerning the transport of both cargo and passengers may be the airship concept, which was submitted in the DHL competition.

The Blue Sky Transport Design Award airship is powered by solar panels, which may generate additional energy from wind, can carry 500 tons of cargo or passengers at speeds of up to 250 km/h[8] (Figure 3).

Figure 3. Airship for transporting cargo or passengers
Source: *14 innovations that will soon unload traffic jams in cities*, https://www.trans.eu/pl/aktualnosci/14-sposobow-na-korki (access: 22.01.2018)

[7] *Ibidem*.
[8] *14 innovations that will soon unload traffic jams in cities*, https://www.trans.eu/pl/aktualnosci/14-sposobow-na-korki (access: 22.01.2018).

An autonomous delivery vehicle or a mobile parcel machine, powered by electric motors (a project also submitted for DHL's competition by designer M. Bakalowitz) may be an interesting concept for servicing urban supply. This vehicle is an ecological solution for urban deliveries. One time it can cover a distance of 120 km and its load capacity is 500 kg (Figure 4)[9].

Figure 4. An autonomous delivery vehicle project
Source: *14 innovations that will soon unload traffic jams in cities*, https://www.trans.eu/pl/aktualnosci/14-sposobow-na-korki (access: 22.01.2018)

Operational solutions primarily include:
– advanced route planning;
– energy-saving driving techniques;
– ongoing traffic monitoring of vehicles;
– intelligent transport systems for better use of vehicles and infrastructure.

Innovative logistics solutions include, above all, activities aimed at facilitating the integration of various transport branches, i.e. creating distribution centers or logistic centers, inter-branch flow of information on transport infrastructure, various types of network integration[10].

2. Innovation in inland water transport

Inland waterway transport is often wrongly perceived as outdated branch. Meanwhile, solutions have been implemented in this branch for many years to adapt the means of transport to new loads, spheres of application, environmental requirements, development of inter-branch cooperation, and thus to implement social, economic and ecological challenges of sustainable transport development.

Technical solutions are manifested first of all in the construction of ships enabling new areas of application of this mode of transport, e.g. river containers or ships used to supply cities (Figure 5).

[9] *Ibidem*.
[10] *Stay on top with the Innovation Radar*, https://eibip.eu/innovation-radar/ (access: 1.12.2017).

Figure 5. The ship transporting DHL shipments in cities
Source: *Alternative ways for distributing goods in Amsterdam: boat & bikes (The Netherlands)*, http://www.eltis.org/discover/case-studies/alternative-ways-distributing-goods-amsterdam-boat-bikes-netherlands (access: 12.10.2017)

An important direction of exploration is the use of alternative energy sources, variable drive sources (hybrid vehicles), as well as reducing energy consumption and pollution reduction, and, as in other means of transport, productivity growth through the use of intelligent transport systems to manage traffic or better use the loading capacity of ships and the implementation of logistic concepts (Figure 6).

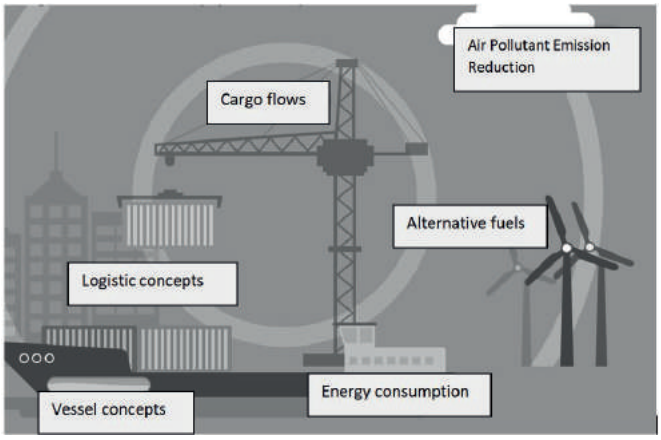

Figure 6. Areas of innovation in inland water transport
Source: *Stay on top with the Innovation Radar*, https://eibip.eu/innovation-radar/ (access: 1.12.2017)

As regards the use of alternative fuels, an especially attractive innovation solution in inland water transport is equipping ships with LNG (liquefied natural gas) engines. In inland waterway ships, these solutions involve the use of drive systems:
– dual-fuel, simultaneously supplied with oil and gas or
– mono-fuel (powered only by LNG).

In ships equipped with dual-fuel engines, both diesel and LNG are used. The main advantage of this drive system, compared to mono-fuel engines, is the possibility of using such ships on waterways without adequate infrastructure enabling bunkering of ships into LNG fuel. The first LNG ship with a dual-fuel engine in Europe ("MTS Argonon" tanker) was launched on November 25, 2011 and since December 2011 it has been operated on the Rhine between Rotterdam and Basel[11].

However, the future solution is an engine powered only with natural gas. The world's first LNG riverboat ("Greenstream" motorboat) was launched in March 2013 and put into operation on the Rhine in April 2013[12]. These ships are characterized by even lower emissions, in particular nitrogen oxides (NOx). However, these ships can only be used on waterways over which LGN bunkering stations are located at the proper distance.

The specific solution for inland waterway transport is the so-called "cold ironing" – ships mooring in the port do not use additional engines, but port facilities used to power ships from land by electricity. The advantage of this technology is the reduction of emissions of harmful substances – the emission level is then reduced to zero – and thus, the degradation of the environmental impact is reduced. In the port of Rotterdam, 160 land connections for inland navigation were installed. Similar devices operate in other seaports and increasingly their introduction is also postulated in inland ports.

The operational innovations, analogous to other modes of transport (enabling, for example, better planning of transport routes, improvement of energy-saving navigation techniques, tracking the current traffic situation), include the River Information Service (RIS). They are harmonized information services that enable transferring information on the navigational situation on waterways, traffic volume, shipping and port fees, allow for proper traffic management, supporting mitigation of catastrophic events, etc. The benefits of using the RIS system result primarily from the possibility of determining the estimated time of arrival of ships to locks and port terminals. These data are provided to sluice and port operators in advance, allowing for flexible scheduling of lock time and port operation. Information on ship's sailing time results in shortening the waiting time for locking and optimization of reloading processes, mainly due to shortening the waiting time for cargo operations.

The concept of autonomous (unmanned) means of transport is a novelty, just like in road or rail transport. One of the most interesting projects of this type is the autonomous container ship (120 TEU) whose devices automatically reload containers. The ship from the so-called series "zero emission" is environmentally friendly (Figure 7).

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[11] *Argonon, LNG Dual Fuel in inland waterway transport, Bestfact, Best Practice Case Quick Info. Green Logistics & Co-modality*, http://www.bestfact.net/wp-content/uploads/2013/08/bestfact_Quick_info_greenlogistics_2-048_Argonon_LNG_Dual_Fuel.pdf (access: 23.01.2018).

[12] P. Złoty, *Barki zasilane na LNG na Renie*, http://gazeo.pl/cng-lng/cng-i-lng-dla-biznesu/przemysl-cng-lng/Barki-zasilane-LNG-na-Renie,artykul,6856.html (access: 23.01.2018).

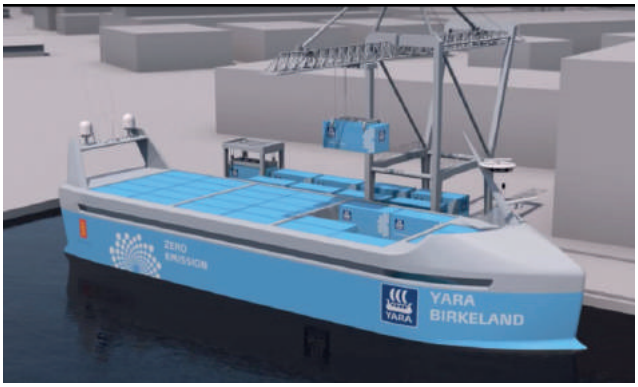

Figure 7. Autonomous container ship
Source: L. Rote, *This Emission-Free Container Ship in Norway is Changing the Industry*, https://gbdmagazine.com/2018/container-ship-yara-birkeland/ (access: 10.01.2018)

Another interesting idea is the Water Strider autonomous hydroplane with electric drive that can carry cargo and passengers. It has the cargo volume of a standard delivery van (Figure 8).

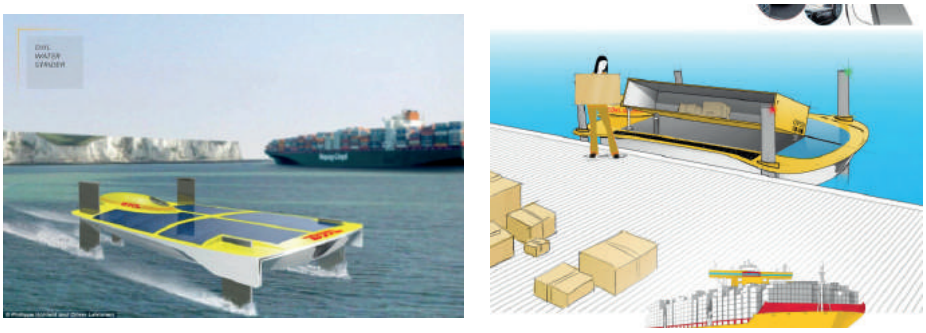

Figure 8. The concept of Water strider
Source: *14 innovations that will soon unload traffic jams in cities*, https://www.trans.eu/en/aktualnosci/14-sposobow-na-korki (access: 22.01.2018)

Among logistic innovations in inland water transport, the concept of creating "dry ports", based on river ports equipped with container terminals, should be mentioned, which thanks to the connection of seaports with the immediate background of the transport branch with high capacity, which is inland water transport, would act as places of cargo concentration and further distribution[13]. The "dry port" and not the seaport are in this concept the destination point of sea transport. Preliminary research shows that ensuring efficient connections between

[13] S. Grulkowski, *Analiza celowości i możliwości budowy „suchego portu" w pobliżu Trójmiasta*, https://www.researchgate.net/publication/283514752_Analiza_celowosci_i_mozliwosci_budowy_suchego_portu_w_poblizu_Trojmiasta (access: 23.01.2018).

a "dry port" and sea and land terminals within a day requires that the "dry port" transshipment capacity should be at least 1 million TEU[14].

The process of separating imported containers into individual relations and individual recipients, according to this concept, is therefore not carried out at sea terminals (due to existing infrastructural constraints) but in "dry ports", in accordance with the hub-and-spoke principle. However, in the case of export, i.e. from the back-up to seaports, "dry ports" would be a place of concentration of containers from different call-sizes and their distribution to individual sea terminals or even sea ports in accordance with their specialization.

It is estimated that, thanks to this solution, limiting logistics activities, in particular limiting the storage processes in seaports, should lead to a reduction of costs in logistic chains, and the higher the more participants will be included in the "dry port" network.

In Poland, despite the problems with the development of inland waterway transport, resulting from the neglect of infrastructure of inland waterways, there are no examples of searching for innovative solutions, primarily in the field of inland waterways drives and their construction solutions.

For several years, solar powered water trams have been exploited. New ideas for this type of ships are also being created. The designers from Nelton Design Office in Pruszcz Gdański designed a passenger ship with electric drive (Figure 9). Like the latest generation of electric cars, ships would be powered by electric motors, powered exclusively by the energy accumulated on them in lithium-ion battery assemblies[15]. Ships designed for the Norwegian ship-owner could be used for passenger navigation on the waters of the Żuławy Loop, including the Martwa Wisła, Przekop Wisły, Szkarpawa, Nogat, Dolna Wisła (from Biała Góra to Kiezmarka) and the Vistula Lagoon.

One achievement in Poland is also the inclusion, from 16 May 2014, of the lower Oder section (97.3 km) of the River Information Services system (RIS-Odra), whose managing body is the Director of the Inland Navigation Office in Szczecin[16]. It is assumed that this system will have a significant impact on the optimization of traffic on inland waterways, improving safety and increasing the efficiency of inland waterway transport.

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[14] H. Kerstgens, K. Kahl, *Perspektiven des Kombinierten Verkehrs mit Binnenschiff*, Internationales Verkehrswesen 2012, 2.

[15] J. Sieński, *Autostrada Wodna na Wiśle. Elektryczne statki mogą stać się naszym przebojem*, http://www.dziennikbaltycki.pl/po-drugie-wisla/a/po-drugie-autostrada-wodna-na-wisle-elektryczne-statki-moga-stac-sie-naszym-przebojem,9827190/ (access: 14.01.2018).

[16] Centrum River Information Service, Office of Inland Navigation in Szczecin, https://szczecin.uzs.gov.pl/sbpuz_o_centrum_ris.htm (access: 23.01.2018).

Figure 9. Eco-friendly cruise ships with electric drive
Source: J. Sieński, *Autostrada Wodna na Wiśle. Elektryczne statki mogą stać się naszym przebojem*, www.dziennikbaltycki.pl/po-drugie-wisla/a/po-drugie-autostrada-wodna-na-wisle-elektryczne-statki-moga-stac-sie-naszym-przebojem,9827190/ (access: 14.01.2018)

Conclusions

Innovations in transport are generally aimed at reducing its degradative impact on the environment through the use of environmentally friendly technical solutions, improvement of logistics processes and better use of existing means of transport and infrastructure.

Inland waterway transport is one of the branches least degrading the environment. However, as has been shown, solutions are also sought in this branch to offer more environmentally friendly solutions. Technical innovations are manifested first of all in the construction of ships enabling new areas of application of this means of transport and the use of alternative energy sources for the propulsion of ships, or the use of a specific solution for inland navigation, which is the so-called "cold ironing". Innovations allow to reduce energy consumption and pollution. Among the operational innovations, analogous to other means of transport, aimed primarily at increasing efficiency and safety in transport, one can notice the use of intelligent transport systems for traffic management or better use of ship capacity and the implementation of autonomous means of transport. Among the logistics innovations in inland water transport, it is worth mentioning the concept of the so-called "dry ports". The article shows that this branch is not inferior to the search for innovative solutions consistent with the idea of sustainable development.

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THE CONCEPT OF AIRPORT OPERATION IN GDYNIA IN THE CONTEXT OF OPTIMIZATION OF SOLUTIONS FOR THE DEVELOPMENT OF AIR TRANSPORT IN THE POMERANIA REGION

Abstract

The article covers issues related to the availability and use of terrestrial ground infrastructure existing in the Tri-City area. Its main purpose is to present and recommend functional solutions that will enable optimal development of air transport in the Pomeranian region. Such a solution would be a described model based on two complementary airports of public use. Thanks to this, the demand for air traffic from commercial users as well as non-commercial users in the area of general aviation will be better met. One of the basic assumptions for the presented solution is the complementarity, and effective use of existing resources and capabilities now and in the future. The whole is based on historical and current quantitative data and forecasts for the development of air traffic.

Keywords: airport, airport management, air traffic, air transport, busines aviation, complementary airports, flight training, general aviation, infrastructure, private flights, regional development

Introduction

Airports are a basic infrastructure element enabling the functioning of air transport. They are an important element of regional development, and their existence is an important factor determining the communication accessibility of the region[1].

Due to the availability of airports for users, we divide them into public and exclusive use. An airport for public use is an airport open to all aircraft on the dates

[1] S. Chakuu, P. Kozłowski, M. Nędza, *Podstawy transportu lotniczego*, Konsorcjum Akademickie, Kraków–Rzeszów–Zamość 2012, p. 113.

and times agreed by the airport manager and made available to the public, whereas the exclusive use airport is used by the airport manager, users named in the airport's registration documentation and with the airport manager's consent – other users. Due to the role in the country's development policy, local (communal, district) and supralocal (regional, domestic) airports are distinguished[2].

There are real barriers to terrestrial air transport infrastructure (airports), which significantly hinder and limit the possibility of their creation and development. These are permanent barriers resulting from the limited natural resources, i.e. environmental protection and spatial development, including existing infrastructure for other modes of transport. The most important temporary barriers include the economic barrier, and other important factors are technical, technological and organizational factors[3].

Facilities such as airports are characterized by large local land use. They occupy a large area, and also force the need to meet certain conditions in their surroundings. This usually leads to restrictions in spatial planning and is associated with a significant impact on the environment. It is more justifiable to look for solutions that rely on the optimal use of existing infrastructure resources. This applies to both commercial transport and other aviation activities – from the broadly understood general aviation. Such an existing resource for the Pomeranian region is the military airport of Oksywie, where activities were carried out for years to start civil activities there.

The very idea of a system approach to the use of aviation infrastructure facilities in the region is not new. Already in 2006, professor A. Ruciński presented the article at "the new quality of transport and logistics after accession to the European Union" Conference, in which he described the concept of construction and operation of the Pomeranian Air Transport Area[4]. In 2010, a research report was prepared for the Ministry of Science and Higher Education – "Strategy for the construction and development of the Pomeranian Air Transport Area", where important premises indicating the purposefulness of such solutions were presented. This study put emphasis on the effective use of the existing ground infrastructure of the Gdansk Airport, and also indicated the potential of two military airports – in Pruszcz Gdański and Gdynia, which were to be designed to form the Node concerned. An important argument for the described solutions was the limitations in the possibility of expanding the Gdansk Airport and the expected use of the Gdansk airport's adaptation reserves with the number of 3.5–5 million passengers during the year[5]. At that time (2010) organizational work on the adaptation of the military airport in Gdynia to civilian operations was in an advanced phase, while in the case of the airport in Pruszcz Gdański, no action was taken in this direction.

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[2] The Act of July 3, 2002 Air law (Journal of Laws of 2011, No. 240, item 1429).

[3] K. Wojewódzka-Król, R. Rolbiecki, *Infrastruktura transportu*, University of Gdańsk Publisher, Gdańsk 2010, p. 39.

[4] A. Ruciński, *The concept of construction and operation of the Pomeranian Airports*, Conference of Departments of Transport and Logistics of the University of Gdańsk: "The new quality of Polish transport and logistics after the accession to the Union European Union", Sopot 2006.

[5] A. Ruciński, D. Rucińska, D. Tłoczyński, P. Gałka, *Strategia budowy i rozwoju Pomorskiego Węzła Lotniczego – Raport z badań dla MNiSW*, University of Gdańsk, Sopot 2010, p. 91–92.

1. General characteristics of air transport in Poland

Since Poland's accession to the European Union, air transport has been one of the fastest growing branches of transport. This can be seen perfectly on the example of Polish airports, which in 2004 served a total of 8.84 million passengers, and in 2017 this number increased to 40 million[6]. During this period, the role of regional airports significantly increased, whose share in the total passenger transport market increased from 31% to 61%[7].

Commercial air transport in Poland is based today (2018) on the network of existing 15 airports. Four of them are relatively new objects, commissioned for use in 2012–2016 (Modlin and Lublin 2012, Radom 2014, Olsztyn-Szymany 2016). The only Polish airport servicing over 10 million passengers annually is the Warsaw Chopin Airport (15.75 million in 2017). It is also the only port in Poland which, according to the classification used by the European Commission, falls into A category (large community airports, over 10 million passengers per year). In B category (domestic airports, 5–10 million) in 2017, the Kraków Airport was located with the result of 5.83 million passengers. Five more airports (Gdańsk, Katowice, Modlin, Wrocław, Poznań) were classified in C category (large regional airports, 1–5 million), and the remaining ones were in D category (small regional airports, less than 1 million passengers per year)[8].

The growth rate of transport has been at a very high level for years and is much higher than in other Western European countries. In the period from 2010 to 2016, the Polish market increased by over 75%. At the same time, transport in the EU-28 countries increased by 25%, and in neighboring Germany "only" by 20%[9]. Such large values and differences in relation to "old Europe" result to a large extent from the fact that Poland has been a relatively new, young and growing market since joining the European Union. However, the continuing trends show its attractiveness and still significant development potential. The current forecast of air traffic expects to reach a level of nearly 95 million passengers in Poland by 2035[10].

The structure of transport (due to the carrier's business model) includes: network, low-cost and charter carriers. However, the main driving force for air traffic in Poland is LCC, in particular the two largest ones: Ryanair and Wizzair, which together account for over 50% of the market share. This is especially evident in the regional airports, where LCC flights represent the vast majority of operations performed.

In addition to typical air transport, the air traffic known as General Aviation (GA) is also developing significantly. The International Civil Aviation Organization (ICAO) defines general aviation operations as "operations involving the use of aircraft, other than those performed as commercial air transport or as part of air

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[6] http://www.pasazer.com/news/37419/raport,ponad,40,mln,pasazerow,w,polsce,w,2017,r.html (access: 15.02.2018).

[7] Civil Aviation Authority, http://ulc.gov.pl/pl/regulacja-rynku/statystyki-i-analizy-rynku-transportu-lotniczego (access: 15.02.2018).

[8] Announcement of the European Commission, 2005/C 312/01, (Dz.U.UE.C.05.312.1).

[9] Based on the EUROSTAT data.

[10] Civil Aviation Authority.

services"[11]. This means that General Aviation (GA) covers a wide range of air operations (private and commercial), from paragliding flights to jet aircraft flights. This is the aviation sector, which in recent years in Poland is characterized by very dynamic growth. This is proved, among others, by statistics of the Polish Air Navigation Services Agency, presented in the chart.

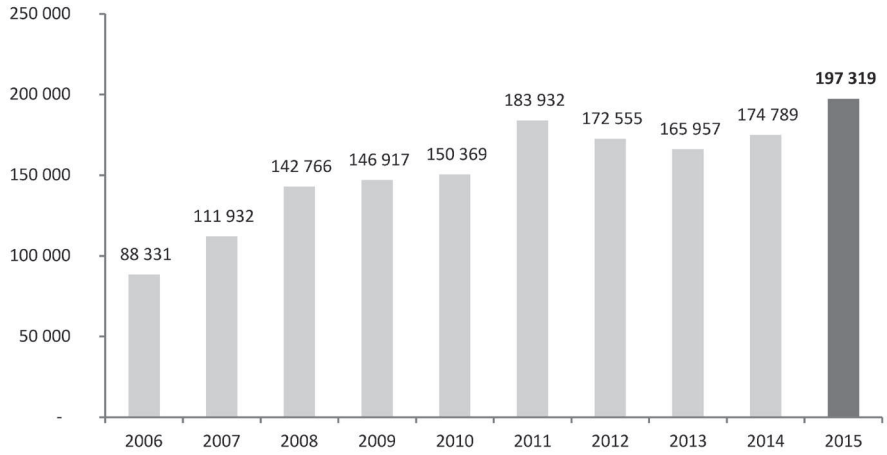

Figure 1. Number of general aviation operations in Poland in 2006–2015 (numbers of connections made with Flight Information Service)
Source: own elaboration based on data of the Polish Air Navigation Services Agency, https://dlapilota.pl/wiadomosci/dlapilota/jest-niezle-widac-ozywienie-w-lotnictwie-ogolnym (access: 15.02.2018)

The actual number of GA air operations in Poland is incomparably greater, as the values presented in the chart refer only to the "number of connections made with the Flight Information Service" and do not take into account the vast majority of flights performed only in areas/zones of airports (e.g. flight training). In addition, it is necessary to emphasize the constantly growing number of private aircraft held by natural persons in Poland. This number according to the data of the Civil Aviation Office, increased in 2010–2016 by 42%[12]. This also indicates a dynamically growing demand for infrastructure and services covering the general aviation sector.

While in the case of typical airports, we can talk about meeting European standards (all Polish airports, obligated under Article 6 (1) of the EU Commission Regulation No. 139/2014 of 12 February 2014 to convert national certificates into European Union certificates, successfully passed the conversion process)[13], while in the case of others – smaller airports, differences in relation to Western European countries remain significant. The number of GA dedicated facilities, especially those that have a paved runway, navigational aids, or adequate infrastructure, is much lower in Poland than in other countries. Particularly noticeable is the lack of generally accessible airports (of public use). The smaller airports and airstrips existing

[11] Annex No. 6 to the Convention on International Civil Aviation, ICAO, Montreal 2008.
[12] Register of Civil Air Vessels of the Civil Aviation Office.
[13] Civil Aviation Authority, http://ulc.gov.pl/pl/247-aktualnosci/4322-zakonczenie-procesu-konwersji-certyfikatow-krajowych (access: 17.02.2018).

in Poland, with a few exceptions, usually operate in a model where the operator also carries out activity appropriate for users, which in practice significantly limits the possibility of locating independent entities that run a competitive activity.

2. Organization of air transport in the region

Air transport in the Pomeranian region is based on the Lech Walesa Airport in Gdansk. This is the third airport in Poland in terms of the number of passengers served. In 2010–2015, investments were made here involving significant expansion of existing infrastructure. They were given, among others, a completely new, second terminal for use, a parallel taxiway was built and new parking spaces for airplanes. The renovation of the runway and the lighting system was also carried out, which translated into raising the category of the airport from CAT I to CAT II. The second category (CAT II) according to the standards of the International Civil Aviation Organization (ICAO) enables performing air operations in atmospheric conditions, when the minimum horizontal visibility along the runway (RVR) is 300 m, and the cloud base is at a height of 30 meters (for CAT I these are 550/60 respectively). All this meant that the operational capacity and airport capacity increased several times. In addition, the accompanying infrastructure was also expanded: access roads and parking lots, and the Pomeranian Metropolitan Railway were opened, thanks to which the airport gained a direct rail connection to the city center.

In 2017, a record number of 4.61 million passengers were served in Gdansk Airport, which is more than a 10-fold increase over the last 13 years. The airport has about 12% share in the domestic passenger transport market and about 4.5% in air freight transport. The capacity declared at present (2018) is 7 million passengers a year. Already, however, new investments are planned, the aim of which is to increase it to around 9 million[14].

Gdansk Airport is the only airport in the region where commercial air transport takes place. Both traditional and low-cost carriers operate here. In addition to commercial traffic, General Aviation flights are also taking place, but, in principle, large communication airports are not the optimal place for this type of operation. This is due to formal requirements, the amount of fees or difficulties and limitations resulting from the specificity and level of commercial air traffic, which is the basic area of activity at this type of airports. The number of operations in Gdansk Airport referred to as "non-commercial" is about a little over 2000 (data for 2015 – the last year for which statistics are available). This represents an increase of 65% compared to 2004 (1254 operations). Increasing the number of commercial operations in the same period from 16 287 to 38 189, as well as a 10-fold increase in the number of passengers in 2014–2017 is confirmed by the commercial profile of the Gdansk Airport[15].

[14] Aviation market, http://www.rynek-lotniczy.pl/wiadomosci/gdansk-w-ciagu-dwoch-lat-rozpocznie-sie-budowa-pirsu-3052.html (access: 22.02.2018).

[15] Data from the website of PL Gdańsk, http://www.airport.gdansk.pl/airport/statistic/ (access: 15.02.2018).

Other objects in the region where civil aviation activity is carried out are[16]:
- Pruszcz Gdański (military airport – aviation activity of the Gdansk Aero Club association, lack of the actual possibility of locating aviation entities other than the Gdansk Aero Club);
- Jastarnia (seasonal, grassy runway);
- Elbląg (Elbląg Aero Club, grassy runway);
- Korne (gliding, paragliding, airplanes in a very limited range, grassy runway);
- Borsk (post-military airport with an artificial runway, currently mainly paragliding);
- Słupsk (Krępa – Słupsk Aero Club, grassy runway);
- Grudziądz (Lisie Kąty – Aero Club, grassy runway);
- Watorowo (FTO Adriana Aviation, commercial training center – airplanes, grassy runway).

None of these facilities is an airport of public use and except Jastarnia, which in the summer mainly serves as a landing site, on each of these landing sites the manager (operator) also conducts activities typical for the user (training, other flights, service, hangar, refueling on own use, etc.)

Founded in 1929, the Gdansk Aero Club association is one of the oldest aviation organizations in Poland. Currently, it is also the largest organization in the field of general aviation in Pomerania. Aero Club conducts airplane, glider, parachute, microlight and ballooning as well as modeling activities. The main profile of the activity is air training – including airplane training. Since 1974, the Aeroclub has been operating at an active military airport belonging to the 49th Combat Helicopter Base in Pruszcz Gdanski, where it has ownership of a small area with its headquarters located there. A certain advantage of the Pruszcz Gdanski airport is a paved runway. However, from its original – a total length of 2.5 km, only a segment of 1162 m is operatively maintained[17]. The use of the runway for civil operations takes place with the consent of the military side and due to the status of the active state airport, it is practically limited to flights as part of the Aeroclub's activity. According to our knowledge, no action has been taken to change this status, and the airport in Pruszcz Gdański is to remain a military facility.

Aircraft training, in the basic scope, is also conducted at the Aero Clubs in Słupsk, Elbląg and in Grudziądz. Due to the fact that the mentioned Aeroclubs have landings with grass surface, their activity is limited to a large extent to the spring – autumn period. The place where there is a relatively large number of flights seasonally is also a landing ground in Jastarnia. The attractive location on the Hel Peninsula causes a large number of external users to use it during the summer. However, its dimensions and location, as well as the lack of additional infrastructure, significantly limit operational capabilities. In practice, this means that only small tourist airplanes, adapted to operate from unpaved surfaces, land here.

The closest – typically commercial air center is FTO Adriana Aviation. The resort is located about 100 km from the Tri-City, in Watorowo. In Adriana Aviation, comprehensive theoretical flight training (including the level of ATPL – Airline Transport Pilot License) has been conducted for many years, practical and simulation to the full

[16] AIP Poland, http://ais.pansa.pl/aip/ (access: 22.02.2018).
[17] *Ibidem*.

extent possible for the GA training organization. It is a private resort, with its own grassy landing ground, enabling night flights (lighting), administration buildings, technical facilities, a hangar and its own hotel base. All this makes Adriana Aviation a significant entity on the national scale, and in the absence of the ability to get a license closer – there are also a lot of people from the Tri-City area.

3. Gdynia Airport – as an existing resource

Oksywie military airport is located about 7 km north of the center of Gdynia. It is used by the 43rd Maritime Naval Air Base. Every day, M-28 "Bryza" planes and helicopters operate here. Formal activities aimed at transforming part of the airport for civilian needs started already in 2005, when with the participation of the Minister of National Defense, representatives of local governments signed a letter of intent regarding the adaptation and expansion of the airport for the needs of a civil airport. According to this agreement, the management of the future Gdynia-Kosakowo Airport was to be entrusted to the Gdansk Airport. However, this idea collapsed and in 2007 the local government authorities of Gdynia and Kosakowo established Gdynia Kosakowo Airport. In December 2010, permission was received from the Ministry of Transport that it was this company that carried out the investment aimed at the creation of a civilian airport, and then managed the launched airport. In accordance with the plans of the shareholders and the management board of the Company, a civil airport was to be created on the base of the military airport of Gdynia-Oksywie, which supplements the air transport services offered at the Gdansk Airport.

The construction works related to the adaptation of the military airfield to civil aviation requirements actually began in 2011. As a result, there were created an access road to the airport, a fence, an administrative and operational building, terminal (not completed), parking lots, fuel base, apron dedicated to GA, as well as a system of illuminating navigation aids.

In February 2014, the European Commission issued a decision indicating that the investment expenditures made by partners (the Municipality of Gdynia and the Commune of Kosakowo) constitute prohibited public aid and ordered their return. As a result, the company carrying out the investment in bankruptcy (from May 2014) was put into operation and the project of building the airport was completely suspended. The municipality appealed against this decision to the General Court of the European Union in Luxembourg and in November 17th, 2017 it issued a decision in which it cancelled the decision of the European Commission. In January 2018, the Commission appealed against this decision to the European Court of Justice. The city of Gdynia, however, has already been negotiating with the Commission much earlier, which, despite the ongoing proceedings by the European authorities, are still ongoing. Their goal is to open the airport and launch civilian operations in Gdynia[18].

[18] Based on internal materials of the Gdynia City Hall.

Currently (2018), in the part of the airport, which has been transferred to civilian activity, objects already in existence are permanently maintained in order to prevent their degradation. It should be assumed that, apart from the terminal itself, which has not been completed, the airport has a ready infrastructure to start operations. These are:

– runway with dimensions of 2500 × 60 m;
– taxiway system;
– apron (aircraft parking) with dimensions of 250 × 40 m;
– additional hardened surfaces (to be used for parking the aircraft);
– fuel base;
– a system of light navigation aids;
– buildings with parking lots and access roads.

The runway, taxiways and aprons form the so-called "Movement Area" (MA). The parameters of individual elements of the MA are fully sufficient for operating the GA operations at the airport. The runway itself meets much higher parameters – also suitable for typical commercial transport operations, but the size of the existing elements (taxiways, apron) that currently allow the airport to obtain the ICAO standard corresponding to the reference code 4B. This translates in practice to the ability to operate aircraft with wingspan up to 24 m[19]. An important element of the existing infrastructure is a modern system of illuminating navigation aids. The airport also has significant field reserves, allowing the construction of facilities for homing and servicing aircraft. The favorable layout of the existing individual MA elements (taxiways, aprons) creates significant opportunities for creating solutions that are conducive to potential users.

In addition to the infrastructure resources mentioned, the Gdynia airport's determination to launch the airport, establishing at the ministerial level (transfer of real estate) and substantive arrangements (speech, instructions) setting out the rules for conducting civilian activities are an important argument for the presented concept. The regulations currently in force (amendment of the Aviation Law) allow the creation of public use airports in the limited certification formula. In relation to earlier regulations in this respect, it creates the possibility of a significant reduction of the costs of the very start-up and operation of the airport[20]. The land use agreement (State Treasury) and the lease of the airport property was concluded for the period up to 2040, but there are no reasons to assume that civil aviation activities at the airport could be terminated after this period[21].

4. The concept of functioning

The presented concept assumes a functional model of air transport organization in the region based on two complementary airports, which on the one hand

[19] Annex No. 14 to the Convention on International Civil Aviation, ICAO, Montreal 2009.

[20] Regulation of the Minister of Transport, Construction and Maritime Economy of 18 June 2013 on technical and operational requirements in relation to public use airports for which a decision on limited certification was issued (Journal of Laws of 2013, item 799).

[21] Based on internal materials of the Gdynia City Hall.

is a continuation of assumptions from previous projects and studies (Pomeranian Aviation Junction), and on the other – adaptation of planned intentions to the current and predicted situation in the field of air traffic organization. Compared to the initial assumptions of the Pomeranian Aviation Junction, this study takes into account the changes that have taken place over the past years, i.e. in particular: the expansion and significant increase in capacity of the Gdansk Airport, the structure of transport in regional ports, and the level of implementation (currently suspended) project for the launch of the Gdynia airport. For the reasons given earlier in the concept, the airport in Pruszcz Gdański was not included, thus limiting the functional model presented to two airports.

The basic assumption for the presented concept – in relation to the functioning of the Gdynia airport, is to create optimal conditions for the development of air traffic, which in the operational scope has been defined as General Aviation, and in the commercial context – as non-commercial. Figure 2 presents a model, where the functional division of different types of aviation activities is schematically shown – in relation to the nature, capabilities and potential of individual airports. The main assumptions here are efficiency and complementarity, and the proportions shown in the figure should be treated conventionally at this stage. However, they are based on some objective and obvious dependencies.

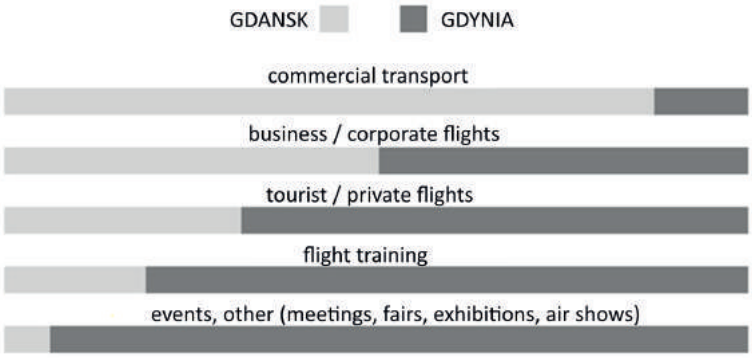

Figure 2. Functional model for air traffic organization in the region – two complementary airports
Source: own elaboration

The dynamically developing Gdansk Airport is already a place where it is difficult to conduct certain operations regarding general aviation – even due to the high volume of commercial traffic. This applies in particular to activities in the field of flight training, but also to tourist and private flights. These problems are not and will not be in Gdynia, where air traffic is limited almost exclusively to military aircraft operations belonging to the 43rd Marine Aviation Base stationed here. Both the current and future-forecasted number of military flights does not constitute and will not be a problem for the anticipated civil activity. This has

been repeatedly confirmed in the agreements and arrangements for the sharing of the airport already concluded with the military side[22].

In the field of typical commercial transport, the role of the Gdansk Airport is obvious and indisputable. This is due to the actual possibilities, equipment and existing infrastructure intended for servicing this type of air traffic. Investments already completed and planned in the coming years are a response to the growing demand in the region. The operational parameters of the Gdansk airport, including the CAT II category (planned upgrade to CAT III), make it meet all the standards expected of a modern airport.

In the field, which was defined as business/corporate flights, a definite shift towards the other object is already visible. Nevertheless, in this respect, the Gdansk airport is also fully functional. This kind of activity is and can still be successfully carried out here. However, the Gdynia airport also creates great opportunities in this area, both in the context of the operations themselves as well as field resources for homing and technical service.

In the area of tourist/private flights, the potential advantage of Gdynia is already very clear. The specificity of the aircraft used for this type of aviation activity, as well as the very nature of the flights, make the "less formal" airports much more preferred. An important factor is also airport charges, which are usually much higher in typical airports than at other airports

Flight training is a type of activity for which the objective difficulties in the Gdansk port are most noticeable. The confirmation is that such flights practically do not take place there, and if they are, they are rather incidental. For the same reasons, no pilot training center is operating at the Gdansk airport. 4.6 million passengers in 2017 and the planned achievement of the level of 5 million in 2018 make the number of commercial operations significantly interfere with possible training, and the specificity of school flights is, among others, on the fact that they are characterized by high frequency of takeoffs and landings performed in a short time.

Commercial activities of PL Gdansk makes it virtually impossible to organize any events, air shows and other open/mass events. Such activities can be successfully implemented at the airport in Gdynia. Although it has not yet been launched as a civilian one, in recent years such spectacular events as the international Red Bull Air Race (2014) took place here, and in 2017 there were air shows that are planned again in 2018. Attractive location favours such projects that are very popular and undoubtedly contribute to the promotion of the region.

Operational and organizational possibilities of two attractively located facilities, one of which (PL Gdansk) is a large, well-functioning airport, and in the case of the other (Gdynia) activities are undertaken to launch the public use airport operation in the limited certification formula, indicate high potential in creating solutions that will respond to the challenges of increasing air traffic. The second airport of public use – dedicated to the GA activity, is an important complement to the existing offer in the field of terrestrial infrastructure for the operation and comprehensive development of aviation activities.

[22] *Ibidem*.

The size and operational parameters of the Gdynia airport, including, in particular, the runway, the layout of other elements of the terrestrial traffic field, as well as the already completed investments also indicate the possibility of commercial operations in the future. However, the possible undertaking of activities aiming at this type of activity should depend on the actual needs in satisfying the demand for air transport in the region, and in particular on the possibility and possible need to support and supplement the transports performed in PL Gdansk. Despite the assumptions currently adopted, i.e. limitations in Gdynia to only the General Aviation segment, it cannot be ruled out that in the future – especially in the event of a capacity shortage at the Gdansk Airport, the infrastructure of the Gdynia airport may also offer its operational capabilities for air transport. In this context, besides the typical "capacity", other aspects are also worth considering, including environmental, spatial and communication. At this stage, however, it is assumed that this would be possible only in the event of a possible agreement in this matter with Gdansk Airport and when it is considered economically and commercially reasonable.

5. Expected benefits

The operation of two complementary airports in the Tri-City will create unique opportunities in the country for the operation and development of air transport, including the wider general aviation segment. It will complement the available infrastructure offer regarding the public use airports with solutions enabling a significant increase in the number of individual users as well as companies from the General Aviation area. It should be assumed that in the case of the emergence of a new, dedicated to the GA facility, the interest in private aviation tourism will increase and the economic potential of the region will be a factor conducive to the development of business aviation.

An extremely important element of the concept is the introduction of solutions enabling development in the field of air training. The signals coming from the market confirm a lot of interest from many entities that are ready to locate their activities in this area. An additional argument is the possibility of combining airport operations with practical training of personnel for civil aviation services. At present, there are three academic centers in Poland (Rzeszów University of Technology, State Higher Vocational School in Chełm and Higher School of Air Forces in Dęblin), in which systematic training in the field of pilotage takes place. In addition, there are many commercial centers where you can get the necessary qualifications to practice the pilot profession. The dynamically developing market creates an increase in the demand for airline personnel. The business plans and the possibilities of using the Gdynia airport are also perfectly suited to this trend.

Air training and training activities usually also influences the amount of private aircraft based in a given location. This in turn makes it necessary to provide adequate facilities and technical service. Also in the scope of providing external services (repairs, airworthiness management), the potential for the development of this type of activity is significant.

An important argument is also the creation of an offer for safe and comfortable homing of aircraft. The possibility of permanent stationing is one of the basic factors influencing the quantitative and qualitative development of GA aviation. The location of the airport, the existing favourable arrangement of elements of the terrestrial traffic (taxiways, plane parking plates), as well as the assumed future functionality of the airport in Gdynia creates great opportunities in this area.

It should also be possible to conduct various activities around the air, i.e. to organize all kinds of events, meetings, shows, exhibitions, fairs, etc. All this makes the potential benefits of starting a civil activity at the Gdynia airport seem obvious and will undoubtedly contribute to the increase of the attractiveness of the entire region.

The growing demand for services dedicated to GA and the lack of a comprehensive, generally available infrastructure offer justify the reality of the concept for the Gdynia airport as an object dedicated to general aviation, which would be a natural complement to the Gdansk Airport. Open and accessible throughout the year, the airport with adequate terrestrial infrastructure, gives the opportunity to safely and effectively conduct a wide range of activities. All this creates conditions for the Tri-City to become an important center for the functioning and development of general aviation, not only in Poland, but also in Europe.

Conclusions

The functional model presented in the concept is based on the complementarity, here understood, as supplementation by the Gdynia airport with offers in the field of terrestrial ground infrastructure, which cannot be and is not complete. This will be ensured by the optimization of conditions for the development of air traffic and broadly understood around aviation activities. It is a solution that enables, above all, the development of all aviation activities from the General Aviation area. The dynamic development of aviation makes it the most appropriate to look for solutions that allow us to meet current and future demand, also from non-commercial air traffic participants. Effective use of the resources already possessed is most desirable here and the infrastructure created and existing at the airport in Gdynia should be used in accordance with its purpose.

Gdynia airport naturally fits in with the presented concept, where apart from the typically commercial aviation activity in the field of transport, the needs of other users were also taken into account. The attractive location of both the Tri-City and the airport in Gdynia means that the demand for air traffic is significant here and will continue to grow. Striving to create a model that would include two complementary airports seems to be the right path, leading to the optimization of solutions for the development of air transport in the Pomeranian region.

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