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Trans-European Transport Corridors as an Element of Poland's Land Use

Introduction

As a EU member state Poland shares its current competencies concerning the policy on transport and trans-European networks with the European Union.[1] The Trans-European Transport Network TEN-T is an instrument which facilitates co-ordination and ensures cohesion and complementarity of infrastructure investment. In the aftermath of a review of guidelines for the TEN-T network accomplished in 2013, its new layout on the territory of EU members was established. This layout includes the core network forming basis of development of the transport network which is to be the focus of EU activities, especially on cross border sections, missing links, multimodal connections and the most important bottlenecks as well as the comprehensive network ensuring accessibility and cohesion of all the Union's regions.

TEN-T issues are regulated by the European Parliament and Council regulation No. 1315/2013 as of 11 December 2013 on EU guidelines concerning development of the trans-European transport network.[2] Trans-European Transport Network (TEN-T) comprises: road, rail, air, sea and river routes representing the most important connections from the point of view of EU development as well as point infrastructure elements in the form of seaports, airports, inland waterway ports or road and rail terminals. Furthermore, its integral element also includes smart transport systems whose implementation contributes to a surge in the network's capacity and traffic security as well as decrease in environmental pollution caused by transport. The aim of TEN-T network development is to

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[1] Article 4 of the Treaty on the Functioning of the European Union.

[2] OJ L 348 as of 20 December 2013, pp. 1–128.

ensure territorial coherence of EU and facilitate free movement of goods and people. Effective transport system within the EU is supposed to contribute to improvement of functioning of the single internal market, stimulate the region's economic growth as well as increase competitiveness of individual member states and the whole EU on the global scale. The aim of the EU policy in the context of development of the TEN-T network is to establish a coherent and interoperational, multimodal transport network characterized by uniform high technical parametres within the whole EU.

The corridors of the core TEN-T network were established with the aim of more effective implementation of this network and accelerated work on infrastructure projects of the greatest European added value. The corridors are supposed to help coordinate different projects on the supranational level. They should contribute to the development of core network infrastructure so as to solve the problem of bottlenecks, intensify cross border connections as well as boost the efficiency and sustainable character of the transport system. They should also contribute to improved cohesion of EU regions through better territorial cooperation. In accordance with EU plans, core network corridors will have been implemented by 2030. The issue of building TEN-T core network corridors was specified in two regulations of the European Parliament and the Council No. 1316/2013 on establishing a new financial instrument called the Connecting Europe Facility (CEF),[3] the exhibit of which specifies the route of these corridors and a list of projects to be financed in the first place from CEF; the regulation also specifies the functioning of the Connecting Europe Facility (CEF) whose aim is to finance investment in the TEN-T core network corridors and No. 1315/2013 on EU guidelines concerning the development of the TEN-T trans-European transport network,[4] regulating organizational issues of functioning of TEN-T trans-European transport.

Guidelines comprising aims, priorities and general directions of activities in the field of trans-European networks were defined in Decision No. 1692/96 of the European Parliament and Council as of 23 July 1996. The current assumptions concerning the TEN-T programme are included in the White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. Its key goals include, for instance, shifting 30% of road freight over 300 km to other modes (rail or waterborne transport) by 2030, and more than 50% of this transport mode by 2050; tripling the length of the existing high-speed

[3] OJ L as of 20 December 2013.

[4] Ibidem.

rail network by 2030 and completing a European high-speed rail network by 2050; connecting all airports belonging to the core network to the rail network preferably high-speed rail and ensuring that all major seaports have good connections with freight rail transport and, if possible, inland waterway system by 2050.

The contemporary European policy pays particular attention to transport corridors which are the pillar of the EU new core transport network. So far divergent systems and connections have been built, which resulted in bottlenecks. Currently great emphasis in Europe is laid on the multinational character of corridors, which proves that they run through a few countries.

This article focuses on that part of the Trans-European Transport System whose elements can be found within the boundaries of Poland. In addition, it refers only to land transport accomplished by means of "land" transport modes, i.e. foot travel, car vehicles (road accessibility) and trains (rail accessibility). In turn, air, inland waterway and sea transport are not accounted for on purpose. The work concentrates on accessibility accomplished by means "land" transport modes.

The aim of the article is to analyze how selected elements of trans-European corridor network are consistent with land use within the boundaries of Poland. The Baltic–Adriatic and Baltic-North Sea corridors comprise both roads and rail lines. In the case of rail the only points which may be included in the traffic are stops, stations or handling points of different kinds. Also the analysis of accessibility to the road network is single-point in character as corridors function on the basis of the highest category roads (motorways and expressways), which are connected with the road network surrounding them only in nodes with slip-roads. This is why analyses of accessibility to the trans-European network are based in this research on analysis of accessibility of points. Cumulative accessibility is the main research method which finds its specification in the subsequent part of this work. Thanks to it it was possible to specify the level of adjustment of corridor routes and their point infrastructure elements to the elements of land development of Poland's space, including its settlement network, distribution of demographic potential or economic activity. Research was conducted for several variants of movement: foot travel, journeys on the road and rail network as well as the multimodal network representing different configurations of the aforementioned transport modes, both for passenger and goods transport. The article presents the situation as of August 2016.

Source Materials and Research Methods

So far transport accessibility has not been defined in one universal and prevailing manner and it is highly unlikely that such a definition will be elaborated in the future. P. Gould[5] points out that accessibility is one of those commonly used terms that everyone uses yet nobody can define or measure it once and for all. One of the definitions most frequently quoted in the literature of the subject is that proposed by W.G. Hansen,[6] according to which accessibility is described as the potential opportunities for interaction. In turn S.L. Handy and D.A. Niemeier[7] stress that interactions should be understood in a broader sense, both economic and social. F.R. Bruinsma and P. Rietveld[8] point at yet another possible definition of accessibility, namely "the ease of spatial interactions" or more precisely as: "attractiveness of a node in a network taking into account the mass of other nodes and the costs to reach those nodes via the network". Among other sources, the authors used in their research data from the Topographic Objects Database (BDOT) obtained from the Provincial Centre of Geodetic and Cartographic Documentation in Warsaw. It is an all-country system of gathering topographic data and making them available which, apart from data, comprises an adequate financing system, organization, IT tools and legal acts. The normative Act which defines standards of this database is the Regulation of the Minister of Internal Affairs and Administration as of 17 November 2011 on databases of topographic objects and databases of geographical objects as well as standard cartographic works.

In turn information about the course and allowed maximum speed on individual sections of the road network was obtained from the resources of the General Directorate for National Roads and Motorways (GDDKiA), Province Roads Authorities as well as OpenStreetMap (OSM) databases. This is a community project which allows to use and edit data under the Creative Commons license.[9]

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5 P. Gould, *Spatial Diffusion*. Resource Paper No. 17, Washington, DC: Association of American Geographers, 1969.

6 W.G. Hansen, *How Accessibility Shapes Land-use*, "Journal of the American Institute of Planners", No. 25/1959, pp. 73–76.

7 S.L. Handy, D.A. Niemeier, *Measuring Accessibility: an Exploration of Issues and Alternatves*, "Environment and Planning A", No. 29/1997, pp. 1175–1194.

8 F.R. Bruinsma, P. Rietveld, *The Accessibility of European Cities: Theoretical Framework and Comparison of Approaches*, "Environment and Planning", No. 30, Vol. 3/1998, pp. 499–521.

9 M. Haklay, *How good is volunteered geographical infromation? A comparative study of OpenStreetMap an Ordance Survey datasets*, "Environment and Planning B: Planning and Design", Vol. 37/2010, pp. 682–703.

Data on the rail network, including its course, train maximum speeds and the distribution of point elements were made available by the PKP Polskie Linie Kolejowe S.A. Company.

Besides, the author included into the research data on the distribution of all settlement units in Poland together with the number of their inhabitants. A central point was generated for every settlement unit and it was given the number of the unit's inhabitants in accordance with the data of the Ministry of Internal Affairs and Administration, the Main Statistical office and City and Municipality Offices.

The last element which was subject to analysis, i.e. totalling in individual isochrones of access, is the general number and distribution of economic entities in Poland with a special focus on those which were classified in section H in the Polish Classification of Activities, so they are connected with transport and warehouse management. The purpose of extending the analysis by companies connected with ensuring the movement of goods and people was to specify the sector's potential in the immediate supply base of transport corridors as units largely fuelled by movements provided in the corridors. Because of the statistical secret the Main Statistical Office made available the above data with accuracy to the basic territorial unit in Poland, which is the commune. A centroid was generated for every (out of 2,478) communes and it was attributed information on economic activities on its area. In the research procedure those central points were totalled in individual isochrones.

Considerations concerning physical distances were ignored at the stage of research into car and rail transport accessibility due to their increasingly marginal importance in the choices of travellers since in practice it is not uncommon that route extension proves cost-effective as it enables achieving a higher speed and performing carrier tasks in a shorter time. The physical distance, however, plays an important role in the case of analyses of foot traffic. In Poland it is customarily assumed that the zone of impact of public transport stops occupies an area of a radius ranging from 500 m to 1 km. This means that inhabitants may access the stop on foot from 6 to 12 min with the assumption that their average speed is 5 km/h.[10] Naturally, this model does not reflect the possibility of generating the demand for public transport services by the stop even if they were provided in all possible directions and with maximum frequency. This results from

[10] B. Majewski, M. Beim, *Dostępność komunikacji publicznej w Poznaniu* [*Accessibility of Public transport in Poznań*], in: *Nowe kierunki i metody w analizie regionalnej* [*New Directions and Methods in Regional Analysis*], eds. T. Czyż, T. Stryjakiewicz, P. Churski, Biuletyn IGSE i GP UAM, Seria Rozwój Regionalny i Polityka Regionalna No. 3, Bogucki Wydawnictwo Naukowe, Poznań 2008, pp. 115–124.

the fact that every inhabitant may have a distinct border distance which marks the point of resigning from using the stop. In addition, apart from the distance, other factors may be important for the hypothetical public transport user, like possible facilities making it easier to access the stop or barriers which hinder such access. The impact of these factors is different for every inhabitant and is strongly determined by individual features of every user, such as age, state of health, sex, place of residence, etc.

Generally, in literature there are methodological problems connected with the border distance for different transport modes. In Great Britain the equidistance of 640 metres is considered the maximum distance of access to the bus stop in town whereas in the case of regional rail or underground it is 960 metres. German urbanists, in turn, assume that the maximum way of accessing the bus stop is 300 metres, the tram stop – 400 metres and the regional rail – 500 metres.[11] Differences in determining border distances in relation to transport modes result from a number of key issues. Greater distances from the train or tram stop as compared to the bus stop decrease the capital expenditure on the construction of new lines with the simultaneous assumption that inhabitants are capable of going longer way to the stop if they can reach their destination quicker and in more comfortable conditions. Consequently, this research adopted a few variants of border distance which the potential passenger must cover on foot to get to the stop. The distance was established using the Manhattan distance metric.

The variant of research into travel time by individual car transport presented in this article assumes only one determinant conditioning the speed of vehicles, namely restrictions resulting from the Traffic Law Act.[12] In this way net travel times were determined, taking into consideration neither breaks resulting from conditions on the road nor breaks allowing the driver to rest or tank. It was assumed that vehicles move at the maximum permissible speed on routes which allow the shortest possible travel time. Consequently, journeys on tolled fragments of motorways were also taken into consideration. While determining accessibility, each time the shortest route in the temporal sense was sought, which did not always coincide with the shortest route in accordance with the real physical distance.

In the part of the analysis devoted to the rail network research proceedings are conducted in accordance with the algorithm adopted for the road network. Only travel times of individual line sections were estab-

[11] W. Loose, *Flächennutzungsplan 2010 Freiburg – Stellungnahme zu den verkehrlichen Auswirkungen*, Öko–Institut e.V., Freiburg 2001.

[12] Act as of 20 June 1997, Dz.U. 1997, nr 98, item 602 as amended.

lished on the basis of the list of maximum speeds for passenger trains, being Apprendix 2.1 to rules of allocating train routes and using allocated train routes by licenced rail carriers as part of 2014/2015 schedule, made available by the PKP Polskie Linie Kolejowe S.A. Company.

The author introduced analysis based on measurements of distance where distance is understood as physical (Euclidean) distance, real physical distance (e.g. road distance), temporal (time of travel/carriage) or economic (cost of travel/carriage) between the source of travel and its destination or a set of destinations and cumulative accessibility. This method is also called isochronic accessibility, where accessibility is measured by assessing a set of destinations accessible in the given time with the given travel cost or effort.

Both in the case of travel and speed of movement resulting from it one fundamental differentiation should be taken into account, namely whether measurements refer to the amount of time necessary to relocate only or the time needed for the whole journey. It is of considerable importance above all in the case of public transport in which the necessity to change and frequency of services play a vital role. In individual transport this factor is of lesser importance yet also in this case the length of journey does not depend solely on the time of drive as in the case of longer journeys it is necessary to have a stopover in order to rest or have a meal, etc., but it is also important to take into consideration restrictions resulting from road conditions. It is a fairly complicated problem which is dealt with by studies from the field of typical road traffic engineering.[13]

The literature of the subject includes different ways of dividing up space into areas demarcated by lines of identical temporal distance. It seems of key importance to consider here the methodology of delineating catchment areas based either on equidistances[14] and real isochrones of access to the given place[15] or geometrical division of space, for instance in the form of tessellation and Voronoi diagrams.

[13] S. Gaca, W. Suchorzewski, T. Tracz, *Inżynieria ruchu drogowego. Teoria i praktyka* [*Road Traffic Engineering. Theory and Practice*], Wydawnictwo Komunikacji i Łączności, Warsaw 2008.

[14] P. Śleszyński, *Możliwości rozwoju regionalnych portów lotniczych w Polsce w świetle uwarunkowań popytowych* [*Opportunities for development of regional airports in Poland in the light of demand conditioning*], „Prace Komisji Geografii Komunikacji PTG", 13/2007, pp. 153–174.

[15] P. Śleszyński, T. Komornicki, *Wpływ rozwoju sieci drogowej na obszary rynkowe istniejących i planowanych portów lotniczych (2008–2015)*, „Drogi. Lądowe, powietrzne, wodne" [*Impact of road network development on market areas of existing and planned airports (2008–2015)*] 9:91–99, 2009.

The above source materials and methodological assumptions gave rise to the following research procedure. The first step consisted in construction of a transport network on the basis of which travel times were subsequently calculated. On this stage every segment of the (pedestrian, road and rail) network was ascribed the maximum allowed speed depending on which type of road it represents. This, in turn, allowed to estimate the segment's travel time and finally choose the quickest routes between adopted points in accordance with the Dijkstra's algorithm. Then all elements of the country's land development subject to analysis were charted on the transport network. Central points were delineated for communes and settlement units so that they can be later calculated in accordance with the cumulative method. The subsequent stage of the research consisted in delineating travel routes between starting points and destinations selected for the analysis. Points on the transport network characterized by the same travel time were joined, forming relevant isolines. Then the author calculated individual elements of development on areas limited by individual isochrones. This procedure was conducted for three temporal scopes: from 0 to 1 hour with 15-minute intervals. The analysis was limited to 30 minutes only in the case of foot traffic.

The Baltic-Adriatic Transport Corridor

The year 2009 was decisive for the idea of the Baltic-Adriatic transport corridor in which intentions concerning interregional co-operation for accomplishment of the VI Pan-European Transport Corridor gained their momentum and progressed.[16] In October 2009, 14 regions from Poland, the Czech Republic, Slovakia, Austria and Italy signed an agreement for immediate realization of the North-South rail corridor (Gdańsk/Gdynia–Warsaw–Brno/Bratislava–Wien–Bologna). Moreover, in December, nine among the aforementioned regions representing Poland, the Czech Republic and Austria signed a declaration about the European and regional importance of the axis of the Gdańsk–Brno–Wien motorway (fig. 1). Moreover, in December, nine out of the aforementioned regions representing Poland, the Czech Republic and Austria signed a declaration about the European and regional importance of the axis of the Gdańsk–Brno–Wien motorway.

The continental part of the Baltic–Adriatic transport corridor stretches from the ports in Gdynia and Gdańsk to ports of northern Adriatic, on the coasts of Italy and Slovenia (including for instance, Trieste, Venice, Ravenna, Koper). Besides that the corridor's branches reach the basins of the

[16] *Baltic-Adriatic Core Network Corridor Study Draft Final Report*, 2014.

Aegean Sea and the Black Sea. The real physical distance of the corridor is 1,700 km (the physical distance between the ports is about 1200 km). The Baltic–Adriatic transport corridor has also its Scandinavian part.

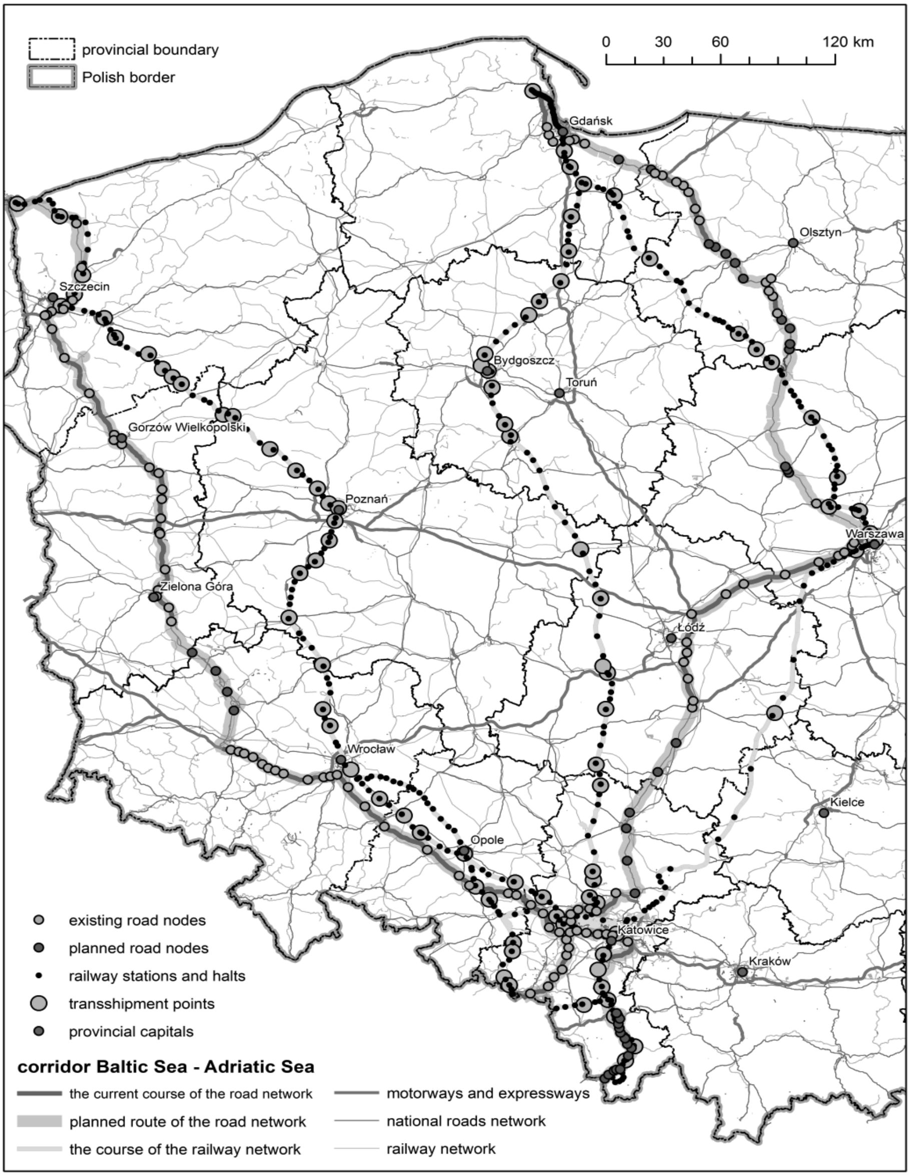

Fig. 1. Point and linear infrastructure of the Trans-European Baltic-Adriatic Transport Corridor within the boundaries of Poland

Source: own study.

The international Baltic-Adriatic corridor on the territory of Poland was originally formed by A1 motorway, E65 railway (line No. 4, 9) and the Polish Coal Trunk-Line (line No. 131). In October 2013 the route of the Baltic-Adriatic corridor was modified to include the so-called Szczecin Corridor. The European Commission extended the initial BAC (Baltic Adriatic Corridor) network by the axis Szczecin/Świnoujście–Poznań–Wrocław–Ostrawa. This decision was caused by the necessity to extend rail and road infrastructure, which should result in potential and real inclusion of ports in Szczecin and Świnoujście into the trans-European transport system. The great significance of the corridor for the functioning of Polish and European transport systems is reflected in the decision of EU institutions to put it on the list of 30 Trans-European Transport Networks TEN-T priority projects.

The construction of the Baltic-Adriatic transport corridor focuses mainly on economic, logistical and technical problems connected with facilitating rail and road connections for the purposes of freight transport.

The success of the Baltic-Adriatic Transport Corridor depends both on infrastructure and economic factors. If the first ones result from linear and single-point investments in the corridor zone, then the latter depend on economic processes generated by infrastructure: mainly movements of goods and people as well as creation of added value. Infrastructure is a necessary, if insufficient, condition to generate movements. Opportunities for successful development may be taken advantage of in a situation when the transport corridor no longer will be treated as an infrastructure bundle ensuring solely transport functions. It should be treated as a development zone axis or, in other words, area of dynamic growth whose functioning and perspectives depend, among other things, on the effectiveness and quality of infrastructure and transport services. In this way both the infrastructure and economic movements generate each other and function in a mutual dependence.[17]

In accordance with the presented research proceedings, analysis included spatial accessibility of the Baltic-Adriatic Transport Corridor resulting from accomplishment of movements by means of different transport modes (fig. 2). A closer look at differentiation of the spatial course of isochrones in Poland's space allows, naturally, to arrive at certain general conclusions concerning the present accessibility of the corridor. Nevertheless it is only the superimposition of areas limited by individual isolines on the country's existing land development that brings some measurable results (tab. 1).

[17] J. Allen, M. Browne, T. Cherrett, *Investigating relationships between road freight transport, facility location, logistics management and urban form*, "Journal of Transport Geography", No. 24/2012, pp. 45–572.

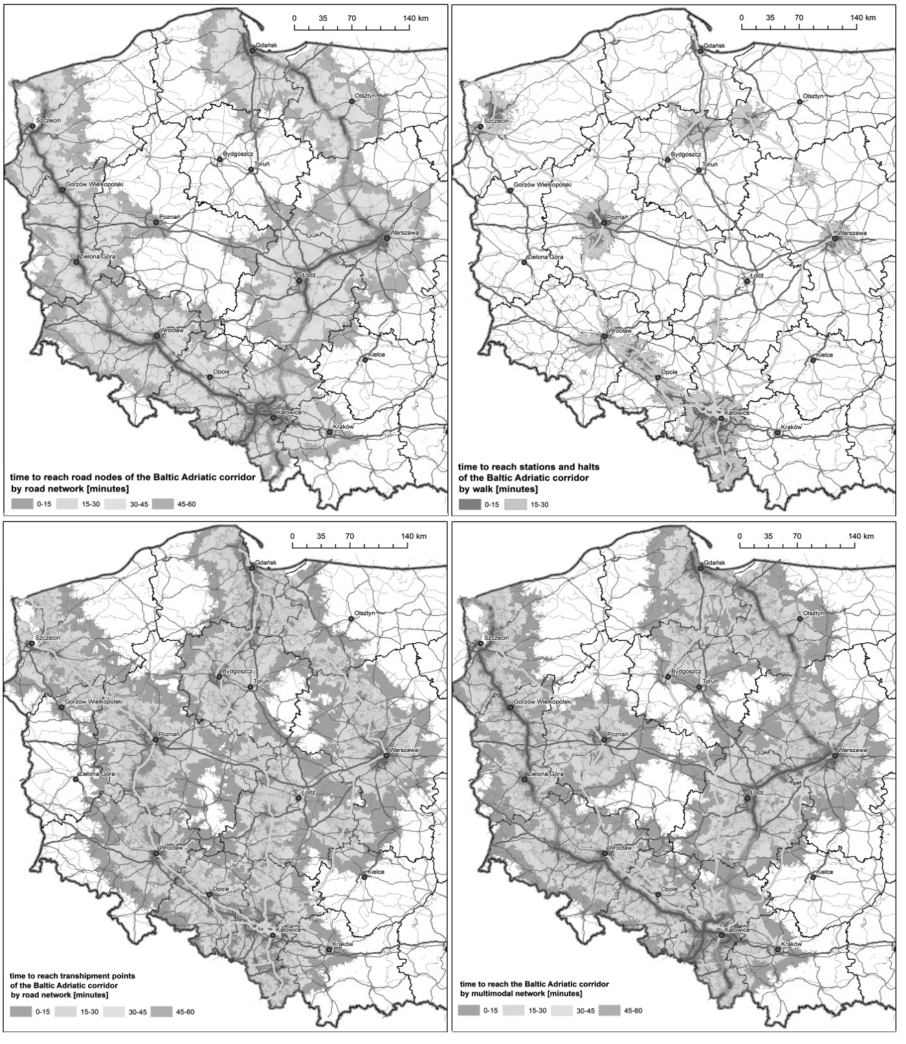

Fig. 2. Spatial differentiation of transport accessibility of the Baltic-Adriatic Transport Corridor within the boundaries of Poland

Source: own study.

Tab. 1. Land development in Poland's space in the scope of one-hour theoretical time of access to the Baltic-Adriatic Transport Corridor

Connection	Travel time	0-15	15-30	30-45	45-60	sum
By road network to existing road nodes	Area surface [km^2]	12297.3	33362.3	40241.9	44521.3	130422.8
	Share [%]	3.9	10.7	12.9	14.2	41.7
	Settlement units	2300	6100	7306	7754	23460
	Share [%]	4.4	11.6	13.9	14.7	44.5
	Population	8770976	5038020	5000047	4339533	23148576
	Share [%]	23.3	13.4	13.3	11.5	61.5
	Economic entities	1307638	454810	565026	482533	2810007
	Share [%]	31.3	10.9	13.5	11.5	67.2
	Economic entities connected with transport and warehouse management	77073	28126	34474	28140	167813
	Share [%]	30.0	11.0	13.4	11.0	65.4
By road network to target road nodes	Area surface [km^2]	16145.1	38554.1	41503.7	43191.3	139394.2
	Share [%]	5.2	12.3	13.3	13.8	44.6
	Settlement units	3100	6946	7521	7463	25030
	Share [%]	5.9	13.2	14.3	14.2	47.5
	Population	10187169	5246355	4439159	3877779	23750462
	Share [%]	27.1	13.9	11.8	10.3	63.1
	Economic entities	1428738	491376	501765	445974	2867853
	Share [%]	34.2	11.7	12.0	10.7	68.6
	Economic entities connected with transport and warehouse management	84257	30275	30867	25689	171088
	Share [%]	32.8	11.8	12.0	10.0	66.7

Connection	Travel time	0-15	15-30	30-45	45-60	sum
By road network to handling points	Area surface [km²]	15218.1	40312.3	49620.1	47940.2	153090.7
	Share [%]	4.9	12.9	15.9	15.3	49.0
	Settlement units	2979	7703	9807	8931	29420
	Share [%]	5.7	14.6	18.6	16.9	55.8
	Economic entities	1377308	572764	708815	394016	3052903
	Share [%]	32.9	13.7	16.9	9.4	73.0
	Economic entities connected with transport and warehouse management	79147	35683	44024	25261	184115
	Share [%]	30.8	13.9	17.2	9.8	71.8
By road network and on foot to stations and train stops	Area surface [km²]	22416.6	44344.4	50507.5	44768	162036.5
	Share [%]	7.2	14.2	16.2	14.3	51.8
	Settlement units	4740	8696	9845	7777	31058
	Share [%]	9.0	16.5	18.7	14.8	58.9
	Population	11503428	6029474	5077911	3992710	26603523
	Share [%]	30.6	16.0	13.5	10.6	70.7
	Economic entities	1510692	664762	556083	399934	3131471
	Share [%]	36.1	15.9	13.3	9.6	74.9
	Economic entities connected with transport and warehouse management	87332	41668	34575	25120	188695
	Share [%]	34.0	16.2	13.5	9.8	73.5

Connection	Travel time	0-15	15-30	30-45	45-60	sum
By multimodal network to all corridor nodes	Area surface [km^2]	18337.5	43852.9	48701.4	45955.8	156847.6
	Share [%]	5.9	14.0	15.6	14.7	50.2
	Settlement units	3511	8081	8911	7846	28349.0
	Share [%]	6.7	15.3	16.9	14.9	53.8
	Population	11354016	5788419	5194534	3516235	25853204.0
	Share [%]	30.2	15.4	13.8	9.3	68.7
	Economic entities	1626613	565513	575163	333528	3100817.0
	Share [%]	38.9	13.5	13.8	8.0	74.1
	Economic entities connected with transport and warehouse management	95283	35342	35212	19681	185518.0
	Share [%]	37.1	13.8	13.7	7.7	72.3

Source: own study.

Another important issue with regard to functioning of transport corridors is the possibility of quick and smooth relocation by means of its networks. In order to determine what this property is like in the case of the Baltic-Adriatic Transport Corridor, the author analyzed the correlation between travel time by road network of the corridor from the south to north of Poland and the physical distance and travel speed, adopting the subsequent node elements as measurement points (fig. 3).

It seems particularly problematic to travel in the scope from about 2.5 to 3.5 and about 5.5 hours from the southern border of Poland as there is a clear drop in average travel speed. Development of Poland's space on this area includes investment intensive areas of the metropolis where transit traffic joins regional and local transport networks, which entails travel speed restrictions. These are the network sections which still did not have the motorway or expressway status of at the time of the research.

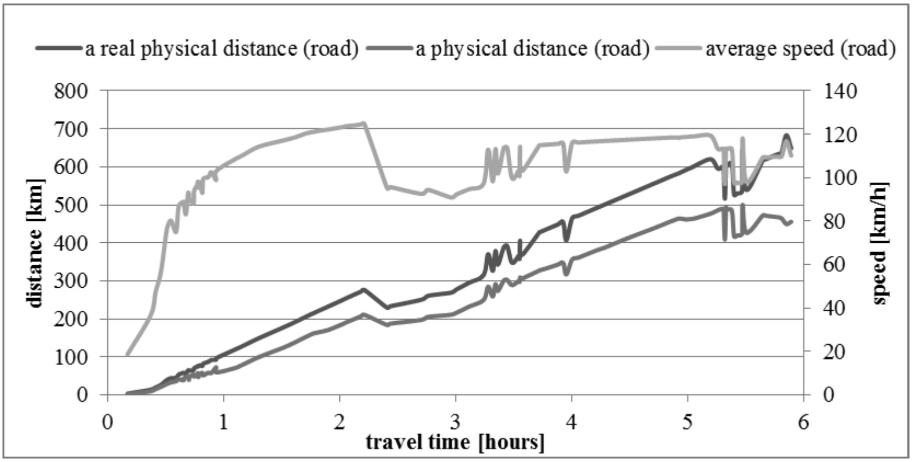

Fig. 3. Changes in the average theoretical travel speed by individual car transport through the Baltic-Adriatic Transport Corridor from south to north within the boundaries of Poland

Source: own study.

The North Sea – Baltic Sea Corridor

The western part of the North Sea–Baltic Sea Corridor on the territory of Poland is comprised by the A2 motorway between the country's border and Poznań (fig. 4). The only fragment not qualified as a motorway is a 1.1-kilometre frontier section between the country's border and Świecko indicated as a dual carriageway national road no. 2. In the subsequent programming period there is no need for additional significant investments in the western part of the corridor. In the scope of the railway network the western part comprises a fragment of the rail line no. 3 (E20; Warszawa Zachodnia–Kunowice) on the section from the country's border to Poznań Główny.

In the 2014–2020 programming period there are no bigger railway investments in the pipeline in the western part of the North Sea–Baltic Sea corridor.

Moving towards east, the North Sea-Baltic Sea corridor in Poland is formed by the A2 motorway between Poznań (Komorniki node) and Warsaw as far as road transport is concerned. Delays and reductions in speed at tollgates remain a problem and, if the traffic continues to increase and the toll system is not changed, may result in bottlenecks in the future, especially in periods of increased traffic.

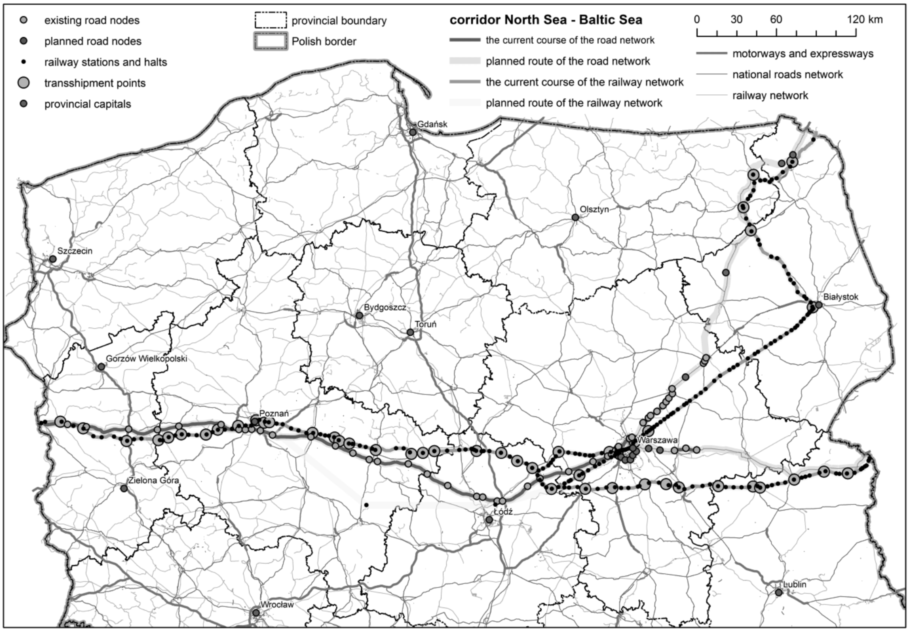

Fig. 4. Point and linear infrastructure of Trans-European North Sea–Baltic Sea Transport Corridor within the boundaries of Poland

Source: own study.

The main element of the east-west rail segment is here the line no. 3 (E20) on the section between Poznań Główny and Warszawa Zachodnia. It is characterized by high operating parametres. The Warszawa Centralna station is connected with the initial fragment of line no. 1. A part of the TEN-T corridor from Łowicz Główny to Warszawa Centralna is dedicated to passenger transport. In turn line no. 11 and 12 (from Łowicz through Skierniewice to Czachówek Wschodni) represent an element of the southern ring road of Warsaw intended for freight traffic.

The corridor also comprises the course of High Speed Rail – line "Y" from Poznań through Kalisz, Łódź to Warsaw which is still in the preparatory phase. Planning this undertaking as part of the new financial perspective will increase the capacity in the course of line no. 3 (E20) and along Warsaw diagonal line. It is very important from the point of view of handling agglomeration traffic which collides functionally on some sections with long distance traffic.

It its subsequent part the North Sea–Baltic Sea corridor in Poland is formed in road transport by the S2 expressway, which is the southern ring road of Warsaw between the Konotopa node and Lubelska node (S17 expressway), and the A2 motorway between the Lubelska node and the border crossing in Kukuryki. As compared to the abovementioned fragments of the corridor, the eastern part is being accomplished as the last one. The year 2013 saw the commissioning of the key fragment of the southern ring road of Warsaw in the form of the S2 expressway between the Konotopa node and Puławska node (together with the section of the expressway no. 79 between the Lotnisko node and the Marynarska node).

In the north-eastern direction the corridor comprises the national road no. 8 from the Konotopa node to Ostrowa Mazowiecka, where the expressway no. 61 from Ostrowia Mazowiecka through Łomża, Ełk and Suwałki to the border with Lithuania in Budzisk will begin its course in the future. The route is in its initial phase and apart from relatively short sections of the national road no. 8 it is the least developed section of the North Sea–Baltic Sea corridor.

The eastern part of the North Sea–Baltic Sea corridor is one of the fragments with the lowest levels of investment from the TEN-T corridors on the territory of Poland. It is necessary to initiate construction works as soon as possible especially on the area of the Warsaw Road Node on the section from the Puławska node to the existing ring road of Mińsk Mazowiecki, as well as on the national road no 8 between Marki and Radzymin or Wyszków and Ostrowia Mazowiecka. This section is the most critical bottleneck of the road system of north-eastern Poland. Yet ultimately the whole S61 should be built as the shortest route connecting the Baltic Sea countries with Poland and Western Europe in the current geopolitical situation. It is also the shortest route for heavy goods transport in the direction of Russia.

Line no. 2 (Warszawa Centralna–Terespol) is the key route in the rail infrastructure of the eastern part of the east-west segment. The condition of this fragment of the E20 corridor (AGC/AGTC) is very good. The technical speed is 120 km/h for goods trains and 160 km/h for passenger trains on the bigger part of the route between Warsaw and Łuków.

The TEN-T corridor in the north-eastern segment is an element the E75 course ("Rail Baltica"). It starts in the Warszawa Rembertów station, connected with line no. 449 with the main Zielonka–Białystok section (line no. 6). Then it goes through Ełk (no. 38), Olecko (no. 39) and Suwałki to the station in Trakiszki on the Polish-Lithuanian border (line no. 51). It was not until 2013 that first modernization works were started on the "Rail Baltica".[18]

Terminals located in the close vicinity of expressways and motorways in the southern, central or western Poland with convenient access to the

[18] *Baltic Transport Outlook 2030*.

nearest node on an expressway or motorway are characterized by the best average road accessibility being a sum of local, national and international accessibility among road and rail terminals in Poland. It is necessary to bring in roads at least in the provincial road category to all terminals over a certain threshold of handling capacity in the whole country.

Bypassing Warsaw in heavy goods transport remains a key problem on the North Sea-Baltic Sea corridor. Nowadays, this traffic uses the so-called external ring road on DK50 and D62 to a larger or smaller extent, depending on the road situation in the capital. In these circumstances further modernization is a vital investment for the North Sea–Baltic Sea corridor, and parallel also for the Adriatic Sea – Baltic Sea corridor (the section from Płońsk through Wyszogród to Mszczonów).

The western fragment of the North Sea–Baltic Sea corridor may be locally prone to excessive traffic and congestion, which results from the location of other road investments. This concerns, in particular, the Warsaw–Łódź section. In the longer perspective it might seem desirable that there be alternative solutions for east-west transit transit. This kind of solution is the parallel accomplishment of S5 (the Gniezno-Bydgoszcz section) and S10 (Płońsk–Toruń–Bydgoszcz) expressways.

In the rail infrastructure a complementary way is the west-southern hand of the planned route of the High Speed Rail (line "Y") from Poznań to Wrocław, ensuring effective connection with the capital of Lower Silesia with Warsaw. It is a key element from the point of view of cost-effectiveness of the High Speed Rail investment as a whole since there is no convenient rail corridor which would connect these two dynamically developing metropolitan areas. The Poznań–Kalisz–Warsaw section itself, entered into the TEN-T network, would not be economically effective in relation to the parallel line no. 3 (E20) without the southern branch.

Spatial accessibility of the North Sea–Baltic Sea corridor resulting from handling traffic flow by means of different transport modes was analyzed in accordance with the adopted scientific proceedings (fig. 5). The spatial differentiation of the course of isochrones in Poland allows to arrive at a conclusion that the multimodal east-west network brings the highest territorially temporal accessibility levels. Nevertheless it was only the superimposition of areas limited by individual isolines on the existing land development that brings measurable effects and allows to make objective conclusions (tab. 2).

It is the point network of rail connections that is characterized by the highest accessibility levels for east-west connections as in the case of the Baltic–Adriatic Corridor also. Due to considerable disproportions between the one-unit east-west corridor and the two-unit north-south corridor, it seems to be a foregone conclusion how the absolute values of their accessibility compare. A comparative analysis may be based on the juxtaposition of results obtained for corridors for individual transport networks.

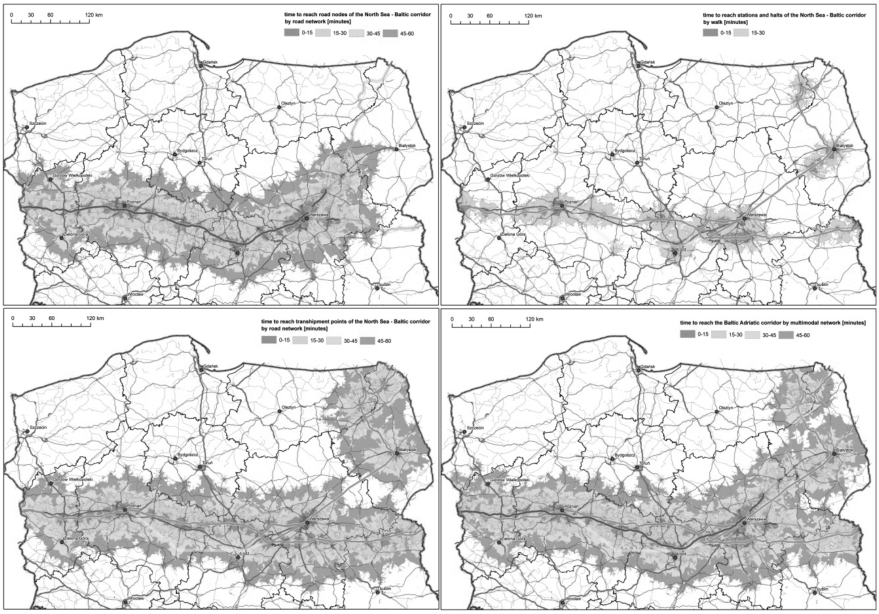

Fig. 5. Spatial differentiation of temporal transport accessibility of the North Sea–Baltic Sea corridor within the boundaries of Poland

Source: own study.

Tab. 2. Spatial development of Poland within one-hour theoretical access time to the North Sea–Baltic Sea corridor

Connection	Travel time	0-15	15-30	30-45	45-60	suma
By road network to existing road nodes	Area surface [km^2]	6449.97	18091.6	20217.1	24878.1	69636.8
	Share [%]	2.1	5.8	6.5	8.0	22.3
	Settlement units	1667	4358	4782	5157	15964
	Share [%]	3.2	8.3	9.1	9.8	30.3
	Population	4649775	2053506	1789209	2316247	10808737
	Share %]	12.4	5.5	4.8	6.2	28.7
	Economic entities	803250	247217	166108	200499	1417074
	Share [%]	19.2	5.9	4.0	4.8	33.9
	Economic entities connected with transport and warehouse management	45482	16150	11288	13409	86329
	Share [%]	17.7	6.3	4.4	5.2	33.6
By road network to target road nodes	Area surface [km^2]	7287.17	20059.8	23892.1	28151.5	79390.6
	Share [%]	2.3	6.4	7.6	9.0	25.4
	Settlement units	1886	4876	5418	5554	17734
	Share [%]	3.6	9.3	10.3	10.5	33.6
	Population	4887758	2114215	1936011	2409904	11347888
	Share [%]	13.0	5.6	5.1	6.4	30.2
	Economic entities	847722	228497	174944	204283	1455446
	Share [%]	20.3	5.5	4.2	4.9	34.8
	Economic entities connected with transport and warehouse management	47801	15818	11763	13663	89045
	Share [%]	18.6	6.2	4.6	5.3	34.7

Connection	Travel time	0-15	15-30	30-45	45-60	suma
By road network to handling points	Area surface [km²]	8605.58	22955.2	28006.3	31812.4	91379.5
	Share [%]	2.8	7.3	9.0	10.2	29.2
	Settlement units	2362	5299	5789	5888	19338
	Share [%]	4.5	10.1	11.0	11.2	36.7
	Economic entities	744543	271257	331595	209199	1556594
	Share [%]	17.8	6.5	7.9	5.0	37.2
	Economic entities connected with transport and warehouse management	43334	17744	21764	13088	95930
	Share [%]	16.9	6.9	8.5	5.1	37.4
By road network and on foot to stations and train stops	Area surface [km²]	12332.5	25420.1	29817	32466.6	100036.2
	Share [%]	3.9	8.1	9.5	10.4	32.0
	Settlement units	3591	5849	6179	5775	21394
	Share [%]	6.8	11.1	11.7	11.0	40.6
	Population	5804412	2318853	2762643	2242095	13128003
	Share [%]	15.4	6.2	7.3	6.0	34.9
	Economic entities	910950	243928	260975	191269	1607122
	Share [%]	21.8	5.8	6.2	4.6	38.4
	Economic entities connected with transport and warehouse management	53825	16100	17295	11909	99129
	Share [%]	21.0	6.3	6.7	4.6	38.6

Connection	Travel time	0-15	15-30	30-45	45-60	suma
by multimodal network to all corridor nodes	Area surface [km²]	9700.15	23212.1	29263.3	31902.4	94078.0
	Share [%]	3.1	7.4	9.4	10.2	30.1
	Settlement units	2727	5558	6181	5998	20464.0
	Share [%]	5.2	10.5	11.7	11.4	38.8
	Population	5570479	2295408	2360793	2569458	12796138
	Share [%]	14.8	6.1	6.3	6.8	34.0
	Economic entities	912739	239624	242435	193041	1587839
	Share [%]	21.8	5.7	5.8	4.6	38.0
	Economic entities connected with transport and warehouse management	53657	15833	16616	12091	98197.0
	Share [%]	20.9	6.2	6.5	4.7	38.3

Source: own study.

It is worth noticing here the relation of the share of Poland's population living on areas covered by individual isochrones between 0–15 minutes and over a quarter with the assumption that the potential passenger will decide to change their transport mode. The possibility of going on foot, by car or train may point to the highest spatial accessibility of the corridor. As in the case of the north-south connection, also here the competitiveness of the multimodal network manifests itself, however, in high accessibility of Poland's population in the isochrones of the shortest time of access to the railway network. This does not translate into a big number of settlement units, which allows to conclude that the multimodal network (including, most of all, its railway segments) guarantees the most effective connection to the country's most densely populated settlement units. This naturally does not translate into an increase in the surface of the area of high accessibility, which results directly from the character of the Polish railway network, which is competitive on some sections in relation to the road network considering travel speed, yet due to its low density cannot compete with respect to the extent of penetrating the country's space. This is particularly visible in the eastern part of the country which stood no chances of developing the rail network when it would have been a natural consequence of economic growth as a result of the invader's policy and nowadays it fails to reduce this backwardness in an adequately dynamic manner.

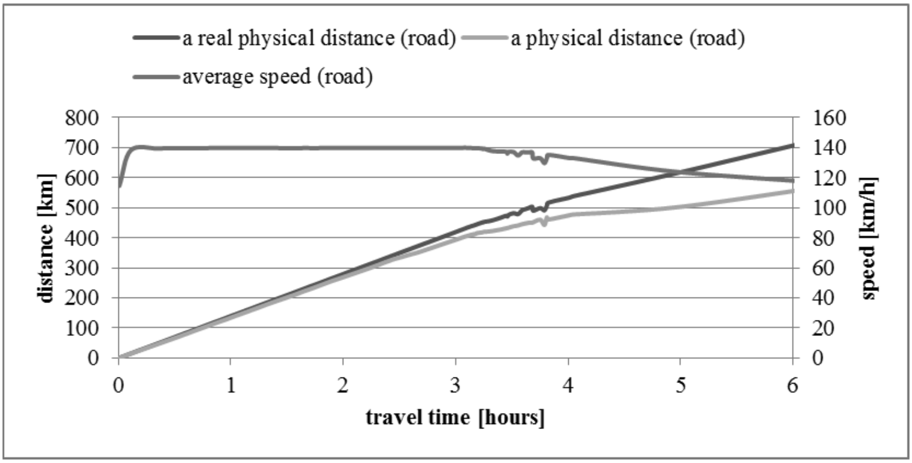

Fig. 6. Changes in the theoretical travel speed by individual car transport in the North Sea–Baltic Sea Corridor from west to east within the boundaries of Poland

Source: own study.

Changeability of travel time by the corridor's road network from west to east was analyzed against the background of incrementing physical distance and average distance as well as theoretical travel speed in order to determine what the speed and smoothness of car traffic is like in the case of travelling on the Polish section of the North Sea–Baltic Sea corridor. Measurements were made for the points where it was possible to join traffic (road nodes) (fig. 6).

The course of the histogram lines illustrating the variables in question is clearly smoother than it was the case with the Baltic–Adriatic Corridor. The theoretical speed does not fall below the maximum speed on a motorway permissible in Poland – 140 km/h for about 3.5 hours of travel from the western border of Poland. This is reflected by a journey on the section of the A2 motorway completed between the western border of Poland and Warsaw. After this section there is a clear disruption in traffic smoothness and on the section of the last two hours of journey to the country's eastern border the speed constantly falls to the average of 120 km/h. This drop results largely from the merely segmental state of the corridor from Poland's capital to the northern east.

Conclusions

Undoubtedly, the highest accessibility levels can be found in the point network of railway lines forming part of the Baltic-Adriatic Transport Corridor. If it is assumed that potential passengers would decide to walk or go by car to stops or train stations devoting less than 60 minutes to it, then railway connections of the Scandinavian countries with the Mediterranean Sea are within reach of over 70% of Poland's population. It is worth drawing attention to changes in accessibility which accompany extending the network of nodal elements of the corridor's road network from the current state to the target one. The investment effort which must be made to develop the network will bring about (assuming that other factors remain unchanged) relatively small changes in accessibility both in its spatial dimension and the cumulative one in relation to settlement units or the number of population.

It seems particularly interesting to observe the connection between accessibility resulting from functioning of a monotransport network and that resulting from travelling by different transport modes. It is worth stressing here the relation of the share of Poland's population living on the areas of isochrones between 0–15 and 15–60 minutes. It might seem that the possibility of relocating on foot, by car or train will bring the highest spatial accessibility of the corridor. Supremacy of the multimodal network can be seen, nevertheless, in high accessibility of Poland's population in the isochrone of the shortest time of access to the railway network. This does not translate into a big number of settlement units, which leads to the conclusion that that the multimodal network (especially its rail segments) ensure the most effective connection of the country's most densely populated settlement units.[19] This does not entail, however, an increase in the surface of high accessibility area, which results directly from the character of the Polish rail network, which on some sections proves competitive in relation to the road network considering travel speed yet due to its low density cannot compete with respect to the extent of penetrating the country's space.

Considering the importance of the the North Sea–Baltic Sea Corridor in international freight flow, one may see really beneficial accessibility levels of handling points on the rail lines forming it. Assuming that potential suppliers would decide on delivering freight by car transport to rail loading points in time not exceeding 60 minutes, then the rail con-

[19] S. Fozza, V. Recagno, *Sustainable Technologies and Innovation for Green Corridors: Survey and Application*, "Procedia – Social and Behavioral Sciences", No. 48/2012, pp. 1753–1763.

nection of countries on the east-west axis is accessible to over 37% of economic entities. The same regularity also concerns companies connected exclusively with the logistics branch. It is also worth paying attention to changes in accessibility which accompany extending the node network of the corridor road network elements from the present state to the target one. Profit, understood as an increase in accessibility for the population brought about by the investment effort necessary to develop the network, will amount to (assuming that other factors remain unchanged) about two percentage points 2%.

All missing network sections should be accomplished in stages with priority given to those representing ring roads and exit roads from big cities and agglomerations. Besides it is highly advisable that node density be increased, especially in the agglomeration areas. Due to very low local accessibility of some road and rail terminals it is advisable to bring in roads at least classified as provincial roads to all terminals above a certain threshold of their handling capacities.

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Key words: Trans-European Transport Network, Transport Corridor, Accessibility, Land Development, Poland

Abstract

The aim of the article is to analyze how selected elements of trans-European corridor network are consistent with land use within the boundaries of Poland. The Baltic–Adriatic and Baltic-North Sea corridors comprise both roads and rail lines. In the case of rail the only points which may be included in the traffic are stops, stations or handling points of different kinds. Also the analysis of accessibility to the road network is single-point in character as corridors function on the basis of the highest category roads (motorways and expressways), which are connected with the road network surrounding them only in nodes with slip-roads. This is why analyses of accessibility to the trans-European network are based in this research on analysis of accessibility of points. Cumulative accessibility is the main research method which finds its specification in the subsequent part of this work. Thanks to it it was possible to specify the level of adjustment of corridor routes and their point infrastructure elements to the elements of land development of Poland's space, including its settlement network, distribution of demographic potential or economic activity. Research was conducted for several variants of movement: foot travel, journeys on the road and rail network as well as the multimodal network representing different configurations of the aforementioned transport modes, both for passenger and goods transport. The article presents the situation as of August 2016.