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Planned spatial arrangement of high-speed railway lines in Poland

Abstract: The article analyzes the main directions of long-distance rail transport in Poland, confronting them with the main directions of population movements in individual road transport, which allowed for the formulation of a general conclusion as to the polycentric rather than monocentric system of the Polish land transport network, in which the main passenger flows are closed in two circles. The smaller circle is formed by Warsaw, Łódź, Poznań and Bydgoszcz with Toruń, while the larger one is defined by the main cities of northern, eastern, southern and western Poland. On the basis of this analysis, a general recommendation was formulated that when designing the spatial and geographical layout of new high-speed railway lines, the layout of passenger flows inside the country should also be taken into account. The new concepts of the geographic route of high-speed railway lines related to the railway component of the project to build the Central Communication Port (CPK) in Poland do not fully take into account this postulate because they have been completely subordinated to the function of transporting and transporting passengers to the planned central airport. In the further part of the article, after a critical analysis of the assumed spatial and geographical routes of new high-speed lines Warsaw - Łódź - Poznań / Wrocław, the CPK - Płock - Grudziądz - Gdańsk line and the designed sections of high-speed lines for the CPK - Rzeszów transport route, specific corrections of their spatial routes are proposed.

Keywords: Railway development in Poland; Railway component of the CPK project; High Speed Railways

Introduction

Poland is a Central and Eastern European country with an area of 312,000 sq. km. and a population of 38.4 million (2021). Since 1990, the country has been undergoing a socio-economic transformation. Poland's land transport system, apart from the network of inland waterways, includes in particular 19.5 thousand km of operated conventional railway lines, including approx. 62% electrified and 1.7 thous. km of motorways and 2.5 thousand km of expressways (2020)[5].

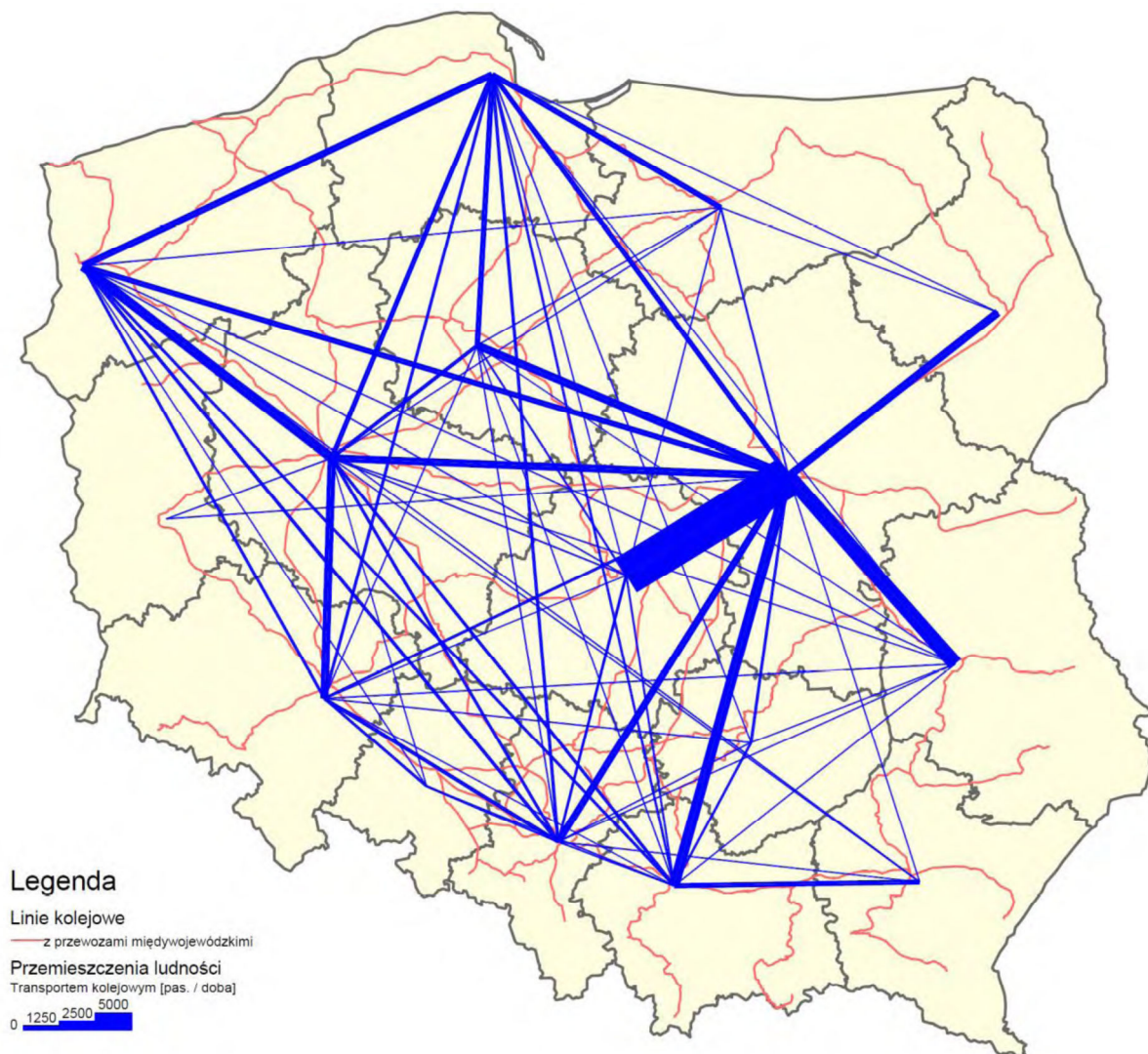
For the needs of one of the subsequent versions of the transport plan of the Minister of Infrastructure [4], studies of inter-voivodship passenger flow in Polish land transport were carried out in 2016. They showed that the main axes of rail passenger transport in Poland are concentrated in the following four spatial relations - see Figure 1:

- Central Poland: Łódź – Warsaw (the largest domestic passenger flow) and further in Podlasie to Białystok,
- Tricity – Upper Silesia and Lesser Poland, connecting Gdańsk with Katowice and Kraków via Warsaw,
- Tricity – Lower Silesia, connecting Gdańsk and Wrocław via Poznań,
- Tricity - Warsaw via Bydgoszcz and Toruń,
- Western Pomerania – Lublin region, connecting Szczecin with Lublin via Poznań and Warsaw,

- Western Pomerania – Warmia and Mazury, connecting Szczecin with Olsztyn via Gdańsk and Elbląg.

For comparative purposes, the cited transport plan presents a map of passenger flows in individual road transport, mapping the aggregated directions of travel by private cars between individual voivodships - see Figure 2.

The analysis of both maps leads to several observations. Firstly, it is clear that passenger flows in individual road transport are usually several times higher in all transport routes where both rail and private car travel are used. Secondly, there is a very clear relationship between the construction projects of new expressways and motorways implemented after Poland's accession to the European Union and the volume of passenger flows in long-distance passenger transport by private cars. Thirdly, the general directions and shape of the transport connections of the Polish land transport network in relation to the flows in the long-distance traffic of people using rail transport and individual travel by private cars are to a large extent similar, although certain deviations from this similarity can be indicated here in relation to the so-called walls of Eastern Poland.

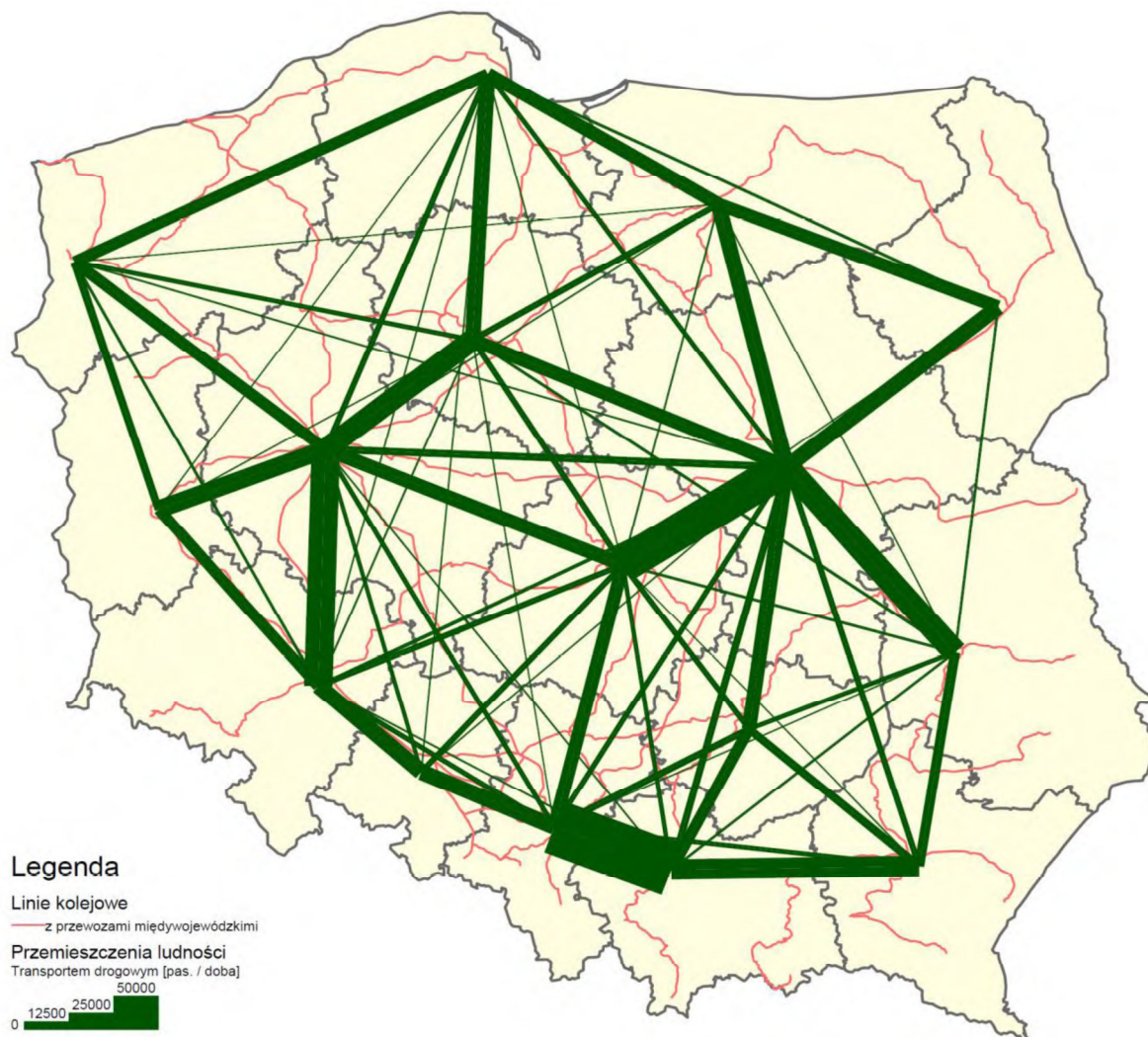


1. The main directions of travel by rail in the field of inter-voivodeship (interregional, long-distance) transport provided as part of the public service - 2016.

Source: [4, p. 30]

In particular, in this case, there are no significant passenger flows in rail transport between Białystok, Lublin, and Rzeszów (see Fig. 1), while the flow of transport by private cars between Lublin and Rzeszów was already at a relatively high level in 2016 with a low stream in these transports on the Lublin – Białystok route (see Fig. 2). This diversity is undoubtedly due to the shortcomings of the historically shaped railway network, which lacks a convenient railway connection between Białystok, Lublin, and Rzeszów, and at the same time lacks a modern expressway connecting these cities. In the future, the indicated shortcomings will be eliminated to some extent.

The general conclusion that can be drawn after analyzing the maps of passenger flows in rail transport and the field of individual journeys by private cars is that the Polish land transport network has a polycentric and not a monocentric layout. The main passenger flows, i.e. displacements.



2. Main directions of movements in individual road transport against the background of railway lines (data aggregation by voivodeships) - 2016

Source: [4, p. 31]

Of the population on the transport network are closed in two circles (loops), the smaller one formed by Warsaw (1.8 million inhabitants), Łódź (668 thousand), Poznań (530 thousand), Bydgoszcz 342 thousand), Toruń (198 thousand) and back to Warsaw, and a larger one created by the Tri-City, i.e., Gdynia, Sopot (together 280,000) and Gdańsk

(471,000), Olsztyn (171,000), Białystok (296,000), Lublin (338,000), Rzeszów (198,000), Kraków (781,000), Wrocław (641,000), Szczecin (396,000), Koszalin (106,000), Słupsk (89,000) and back to Tricity [5]. Within the indicated large circle, there are numerous flows of population movements in the north-south and west-east systems, and vice versa. It should also be emphasized that the majority of passenger flows identified in individual journeys by private cars coincide with the passenger flows identified in rail transport. Given that this is long-distance inter-voivodeship traffic, this fact indicates that there is a field for potential competitive influence and taking over by rail transport parts of long-distance traffic carried out by private cars, as well as parts of the streams generated by long-distance bus transport and domestic air traffic not included in the maps shown. In addition to many conditions for the emergence and continuation of such a process, desirable for social, ecological, and economic reasons, the most important is undoubtedly the creation by the railway of an attractive and competitive transport offer based on modern railway infrastructure, in particular, new high-speed railway lines (High-Speed Railway for short).

The origin of Polish HSR projects

Due to the layout of the Polish railway network, which is cross-shaped with the main passenger streams along the north-south and east-west axis, passing to and from or transiting through Warsaw, the first plans, or rather initial concepts, for the construction of Polish high-speed railways concerned the above-mentioned geographic and economic axes. spatial. In the scientific community dealing with the issues of rail transport, it is often emphasized that the Polish high-speed railway was a kind of leaven for the construction of the Central Railway Main Line (CMK), which is currently a section of the TEN-T core network line marked as E 65, because already at the design stage, parameters were taken into account to adapt in the future, to a speed of 200 - 250 km/h (properly large radii of curves were used - 4000 m and a sufficiently large distance between the track axes - 4.5 m). Thus, in accordance with the currently used classification, this line, and other conventional lines after modernization to the maximum speed parameter of 200 km/h and higher will be classified as high-speed lines. In addition, after the construction of the CMK, it was planned to extend this line from Warsaw, on the eastern side of the Vistula, through Wyszogród, Płock, and Brodnica to Gdańsk, with a branch to Olsztyn [6]. The environmental name Northern CMK was adopted for this project.

In the first years of the period of economic transformation in Poland after 1989, there were no objective conditions for the construction of new high-speed railway lines, but nevertheless, in the years 1990-1995, the first works on the Polish HSR program were started, under which it was assumed that in the years 2010-2030 built two new high-speed rail lines, namely:[8]

- in the east-west corridor: line E 20 bis: western border of Poland - Poznań - Łódź - Warsaw - eastern border of Poland, 660 km long, adapted to the speed of 300 km/h, only for passenger traffic,
- in the north-south corridor: northern CMK Warsaw - Płock - Gdańsk; with a length of 371 km, adapted to a speed of 300 km/h, only for passenger traffic.

Although such projects at the time of their creation were rather futuristic and unrealistic, they left a permanent mark and conceptual leaven for later years, because they became and remain the most frequently considered projects for the construction of high-speed railway lines in Poland.

It can be assumed that the later project of the construction of the Warsaw-Łódź-Poznań/Wrocław HSR line and the modernization of the Central Railway Main Line, which was born in the years 2005–2008, was adopted for implementation in the form of a resolution of the Council of Ministers in December 2008, then in 2011 was suspended, and finally, after completion of basic studies, including an extensive feasibility study in 2013, was rejected in

2015. This project was to consist of a new high-speed line Warszawa - Łódź - Poznań/Wrocław (the environmental name Y line was adopted, due to the characteristic shape on the map) with a length of approx. 484 km with a maximum speed of 350 km/h and upgraded to a high-speed line, i.e. up to the 250 km/h parameter of the E 65 Południe (CMK) line from Warsaw to Katowice and Kraków (373 km in total, including 150 km of new line sections as an extension of the CMK to Kraków and Katowice) with possible later extensions to the border with Germany and the Czech Republic. In addition, it was planned to build a conventional line Łódź – Opoczno (partly along the existing track) aimed at creating a connection between line Y and CMK, with a length of 74 km. Although the HSR Y project referred to the concept of the E 20 bis line from a decade ago, it differed from it in several important elements. Firstly, the new Y line in the western part of Poland was to reach Poznań and Wrocław after a fork towards both cities in the Ostrów Wielkopolski area at Nowe Skalmierzyce station. Secondly, in the east of the country, it was limited to Warsaw, and thirdly, it was assumed that this line would enter directly into the center of Łódź. In 2010, as part of the HSR Y project, a decision was made to build a new underground multimodal station at the Łódź Fabryczna station, adapted to serve high-speed trains, which was completed in December 2016.

New concepts of the Polish HSR route

Since 2017, the construction of the Central Communication Port (CPK) in Baranów (30 km from the center of the capital) has been a declared strategic project of the Polish government, which has resulted in quite significant changes in the approach to the construction of high-speed railway lines [10]. The implementation of this project has been confirmed in the basic transport policy document entitled "Strategy for Sustainable Development of Transport until 2030" [11]. In 2018, the Sejm passed an act specifying the management of the CTH construction program [13]. This project involves the construction of a new Polish central airport near Warsaw, connected to every major Polish agglomeration except for Szczecin. In the aforementioned resolution of the Council of Ministers regarding the STH, there are extensive references to the necessary projects in the field of railway infrastructure related to the service of the new airport. It is envisaged that after the launch of the CTH, the new airport will serve 35-45 million passengers a year, with a significant proportion of passengers arriving and departing from the airport using railways as the most preferred means of transport to serve the CTH [10]. It was also assumed that the location of the CPK in Baranów, thanks to which the capitals of 14 out of 16 Polish voivodships are located within a radius of 300 km, including all metropolitan centers of the country except Szczecin, makes it possible to connect most of the domestic urban centers with this port within 2 hours using trains with speeds in the range of 200–250 km/h [10]. In addition, it was assumed that the new sections of the line will be routed in the footsteps of the railway network development projects prepared in earlier periods, such as the high-speed rail projects Warszawa - Łódź - Poznań/Wrocław (KDP Y) and the Central Railway Main Line Północ (CMK Północ) and connected with the existing network, while the assumed initial standard of newly built lines following earlier high-speed railway projects will be their adaptation to the speed of 250 km/h with geometric parameters enabling a possible later increase of these speeds to 300-350 km/h [10].

The construction project of the Central Communication Port provides that, as part of the railway component, the following lines or their sections will be built as new or modernized to a maximum speed of 200 km/h by 2035:

Zero stage:

- construction of a new railway line Warsaw - STH - Łódź Fabryczna, along the high-speed line "Y" already routed in the past,

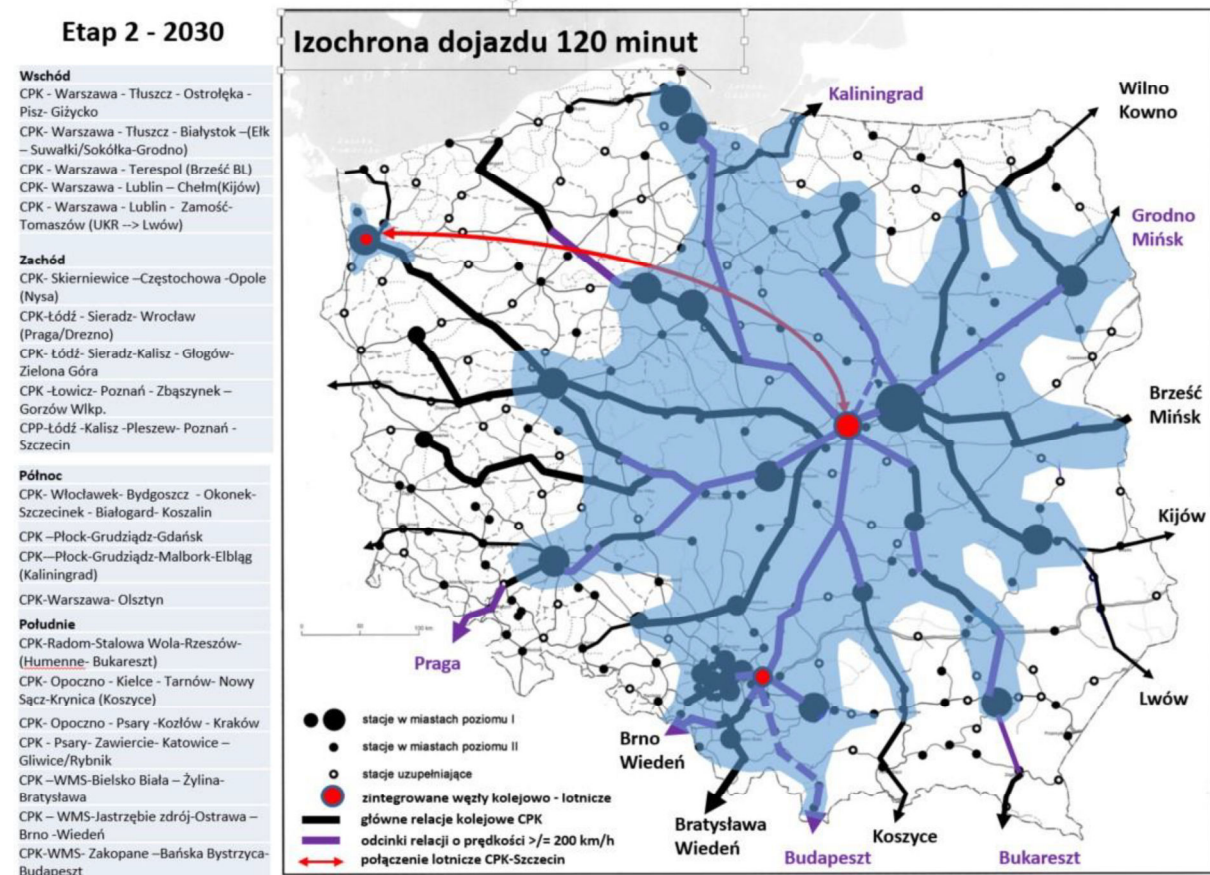
First stage:

- construction of a new section of the HSR line Sieradz - Wieruszów, with a maximum speed of 250 km/h,
- construction of a new section of the Kalisz-Pleszew HSR line, with a maximum speed of 250 km/h,
- construction of a new section of the Nakło nad Notecią - Okonek line, with a maximum speed of 200 km/h,
- modernization of the southern section of the E 65 line (CMK) to the speed of 250 km/h,
- modernization of the Warsaw – Białystok line (Rail Baltica) to a speed of 200 km/h,

Second stage:

- modernization of section E 65 north Warsaw - Działdowo, maximum speed 200 km/h,
- construction of a new section of the HSR line Łódź - Sieradz - Kalisz, in the wake of the HSR "Y" project, as a supplement to the new sections of the HSR line (Sieradz - Wieruszów and Kalisz - Pleszew) built in the first stage, maximum speed 250 km/h and a new section of the line KDP Ligota – Czernica,
- construction of a new high-speed line CMK north: STH - Płock - Włocławek - Grudziądz - Tczew - Gdańsk, maximum speed 250 km/h,
- construction of new sections of railway lines for the CPK-Rzeszów transport route: CPK-Warka, Radom-Ostrowiec Świętokrzyski and Stalowa Wola - Rzeszów, maximum speed 200 km/h,
- construction of a new section of the line branching off from the CMK (partly along the existing route) Opoczno - Kielce, maximum speed 200 km/h,
- construction of an extension of the CMK modernized to the speed of 250 km/h in the first stage to the south to the Śląsko-Małopolski Junction along with the construction of the new Katowice-Kraków high-speed line, maximum speed 200-250 km/h,
- construction of new cross-border sections of the HSR: Wałbrzych - Lubawka (direction Praga), Czechowice Dziedzice - Zebrzydowice (direction Ostrava, Brno), Rzeszów - Sanok (direction Bucharest), maximum speed 200 km/h.

The new high-speed lines built and the existing conventional lines modernized to a speed of 200 km/h, as graphically represented in Figure 3, will, according to the creators of the Central Communication Port construction program, form a network of Polish high-speed lines in the future. In the context of these plans, the planned investments related to the Rail Baltica project should also be considered. It is probable that two sections of the Rail Baltica project, namely Białystok - Ełk and Ełk - Suwałki - border with Lithuania, not marked in Figure 3 as sections with a maximum speed of 200 km/h or more, after modernization and reconstruction, will obtain the parameters of the HSR line, which expected from Poland by the European Commission, which is particularly supportive of this project.



3. The 120-minute access isochrone to the CTH and main routes, including sections of railway lines with a speed of 200 km/h or more - stage two.

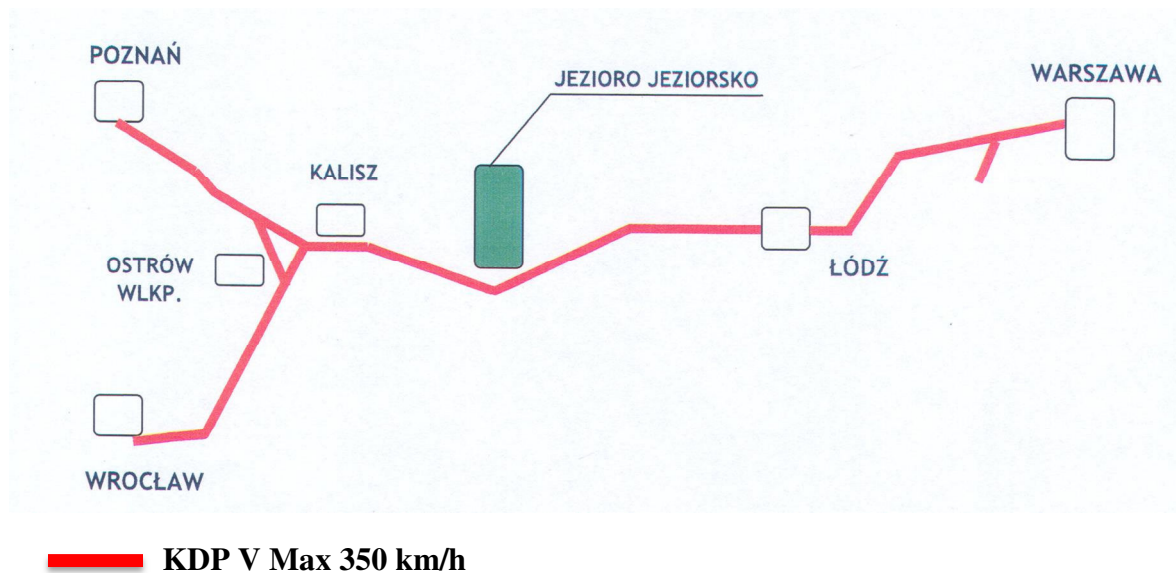
Source: [10, attachment 3]

The general conclusion that comes to mind after the analysis of the list of planned investment projects and their geographic and spatial representation on the map of Poland under the new concept of Polish high-speed railways is that high-speed railway lines are to be used in the future primarily and in the first place for the delivery function and pickup in relation to the Central Communication Port for most of the territory of Poland, and in the second place, and as a complementary service, to serve the international transport connections between Poland and neighboring countries, except for Germany. The absolute subordination of the planned high-speed lines to the first of the above-mentioned functions meant that the hitherto planned high-speed lines were marked with new or changed spatial and geographical routes (line Y, Northern CMK) and new railway connections of the CTH with high-speed lines or with the use of such lines with cities was planned such as Rzeszów, Kielce, Koszalin.

According to the author, the entire high-speed rail component included in the currently pushed concept of building the STH is burdened with a defect in the form of ignoring the fact that the Polish land transport network has the aforementioned clearly polycentric and not monocentric layout, and therefore even the construction of a central airport cannot and should not be a reason for the costly construction of the entire network of new high-speed lines. Until 2022, no new section of the HSR was built in Poland, but construction was announced (without specifying the start date) of the section of the HSR line Warszawa - STH - Łódź Fabryczna, which in terms of geographic and spatial course is consistent with the earlier construction project adopted in 2008 for the HSR line Warsaw - Łódź - Poznań/Wrocław and as such it does not raise any controversy. In this situation, various corrections of the spatial and geographical course of the remaining sections or entire HSR lines are still possible. In this

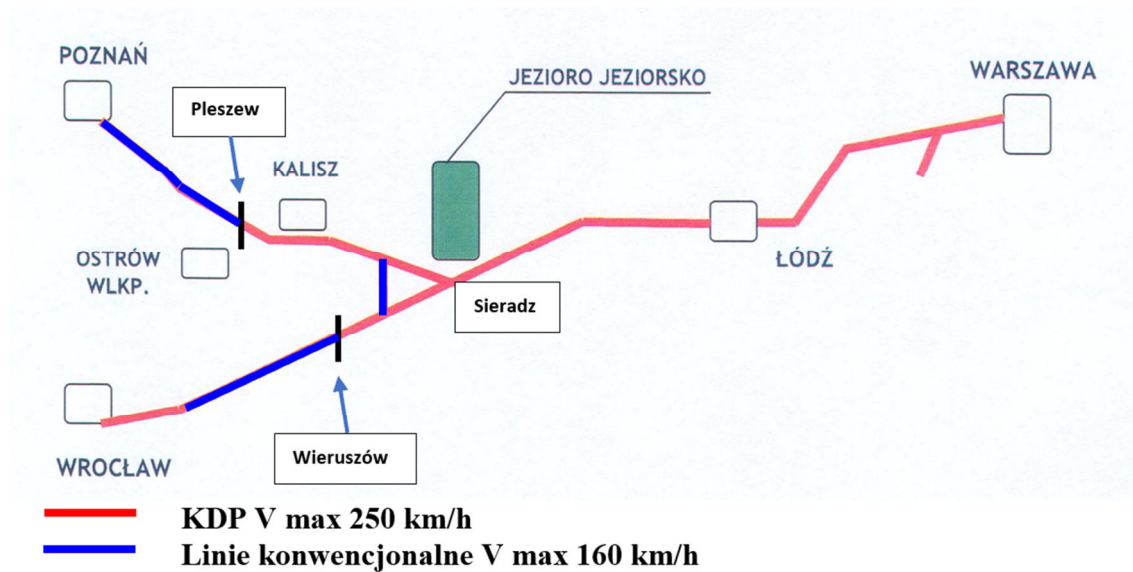
context, the following critical remarks should be treated as a public voice in the discussion on the shape of Polish high-speed railways with their planned spatial and geographical routes, leaving aside the discussion of whether new high-speed lines should be built with a maximum speed of 250 km/h or 350 km/h.

The government's declaration regarding the construction of the HSR Y line would be a full reference to the design of this line from 2008 if it had not introduced significant changes that raised critical comments regarding the route of this line from Łódź to Wrocław and Poznań. It can be recalled here that in the 2008 HSR Y line construction program [12], it was assumed that the line would run to the centers of Poznań and Wrocław, while the available government publications, including the available maps, do not indicate this. For example, in Figure 3, the source of which is the relevant Resolution of the Council of Ministers, the limitation of the range of the new HSR line Y to Pleszew in the Poznań direction (90 km from Poznań) is visible, while in the Wrocław branch of this line, there is a break in its continuity from Wieruszów (100 km from Wrocław). In subsequent government documents, it is difficult to find clear information or declarations regarding the adopted maximum line speed parameters included in the so-called spokes, and therefore it cannot be unequivocally stated whether the section of the Pleszew - Poznań line is to be conventional or will have higher speed parameters [see, e.g., 9.7]. However, the missing sections can always be added at later periods, which makes this drawback much less controversial compared to the shifting of the branching of the new line Y already in Sieradz instead of, as planned earlier, in Nowe Skalmierzyce located between Kalisz and Ostrów Wielkopolski, i.e., about 60 km further in the eastern direction, closer to Łódź. The essence of the differences between the concept of the spatial layout of the HSR Y line according to the original version and the changed spatial layout of this line under the new government project related to the construction of the CTH is presented in the diagrams in Figures 4 and 5.



4. Scheme of the route of the HSR Y line according to the variant adopted in the years 2008 - 2011.

Source: [1, p. 221]

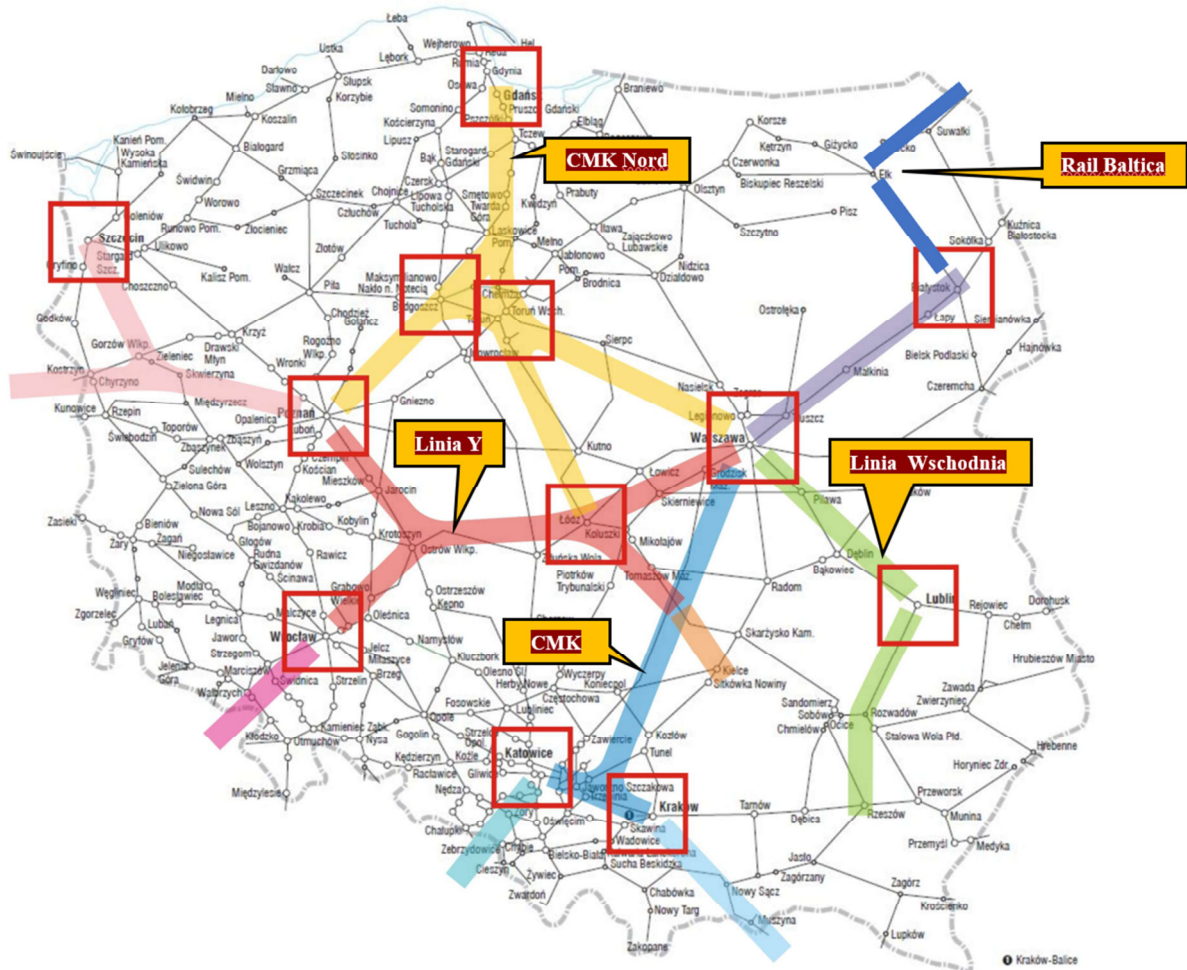


5. The changed diagram of the route of the HSR Y line according to the variant adopted in 2017 as part of the CTH construction concept.

Source: [1, p. 223, own elaboration]

If the fork of the line in Sieradz is moved, as shown in Figure 5, it will not be possible for railway carriers to offer an attractive high-speed line connection not only between Wrocław and Poznań, but also further to Bydgoszcz and Gdańsk. The connection of Wrocław and Szczecin using the HSR line, as well as Poznań and Wrocław with Opole and Katowice, will not have the advantages of transport attractiveness.

As part of the concept of the Central Communication Port, it was declared to build the second important high-speed line, which has been discussed in Poland for several decades, CMK North with the following route: CPK - Płock - Włocławek - Grudziądz - Tczew - Gdańsk. In this case, it is seriously doubtful that this line will completely bypass the Toruń-Bydgoszcz agglomeration. According to the author, CMK North should perform not only the function of transporting passengers to and from the CTH but also integrate the Tri-City (Gdańsk/Sopot/Gdynia) with the south and south-western parts of Poland. For this reason, it is more rational to carry it out in the way it was presented in the study of the Railway Institute in Warsaw from 2010 containing the guidelines for the development of the Polish high-speed network until 2040 - see Figure 6.



6. Main corridors for the construction of high-speed lines.

Source: [2, p. 17]

As emphasized in the cited study, this line would be of key importance for achieving the cohesion of the country and would ensure the communication connection of Gdańsk Pomerania, and Kuyavia with central Poland and via the Y and CMK lines with the main agglomerations of southern Poland with a travel time of up to 3 hours [2]. In the northern section, it would run from Gdańsk basically along the A1 motorway and then branch off towards Bydgoszcz and further on to Poznań [2]. The second branch would run east of Toruń with the Toruń KDP station and further to Włocławek, Płock, and the Grodzisk Mazowiecki junction, which is the intersection of lines Y, CMK, and CMK Północ, and then line Y to Warsaw. A line with the parameters of a high-speed line would be built between Bydgoszcz and Toruń, which would also enable the launch of train connections in the loop from Gdańsk via Bydgoszcz and Toruń and further to Warsaw and Łódź.

Not all declarations of the construction of new high-speed lines as part of the CTH railway component elicit critical comments from the author as to their spatial and geographical course. An example of this is the planned extension of the modernized CMK to the south to the Śląsko-Małopolski Junction, along with the construction of a new high-speed line between Katowice and Kraków. Aware of the fact that there may be critical opinions regarding this project in Silesia, a branch from the CMK towards Olkusz and a high-speed railway line between the capitals of Upper Silesia and Lesser Poland would create a completely new quality in the Polish transport system in terms of connections between Krakow and Katowice with Warsaw and the Tri-City as well as with Opole, Wrocław,

Poznań, Szczecin. In addition, thanks to this investment, the existing section of the E 30 line between Katowice - Kraków would be relieved of long-distance traffic, and the released capacity could be used for freight and regional passenger traffic.

When analyzing the spatial and geographical layout of the new lines or sections of the HSR planned under the CTH project, one should also refer to the concept of connecting an important city in south-eastern Poland, namely Rzeszów, with the central airport near Warsaw. As part of this connection, it is planned to build three new, short sections of the line with a speed of 200 km/h (CPK - Warka, Radom - Ostrowiec Świętokrzyski, Stalowa Wola - Rzeszów). In general, it can be stated that they require further study and are not investments of priority, and in particular, a scientific and expert study would be desirable as to the legitimacy of the idea of "segmental" in the construction of new high-speed railway lines. The author thinks that this kind of idea of building new HSRs, taking into account the geography of Poland, is not justified. Regarding the new HSR sections for the CPK - Rzeszów connection, the creators of this concept can be asked a rhetorical question: if we are to build a new HSR connection from the central airport to the capital of Podkarpacie, why is the Lublin region omitted in this planning. It should be noted here again the study of the Railway Institute from 2010, already quoted, in which a new Eastern Line Warsaw-Lublin-Rzeszów was planned, potentially in the future with a branch to Lviv (see: Figure 6). This line would be of key importance for the integration of the so-called "eastern wall" with the center of the country and the regions of western Poland.

The other high-speed lines planned for construction under the CTH project are various domestic and cross-border sections, both those that were previously indicated in various conceptual works as well as those that have never appeared in any expert studies or even discussions in transport circles. An analysis of the legitimacy of their construction would require a separate discussion. In general, it can only be said that they require further study and are not investments of the highest priority. Such an analysis would be required in particular by the planned construction of a new section of the line with a maximum speed of 200 km/h Nakło nad Notecią - Okonek, with the initial hypothesis of a low probability of generating a passenger flow in the direction of the STH - Koszalin / Kołobrzeg justifying the economic efficiency of this investment. The cross-border sections of the HSR that have been considered for many years include the section Wałbrzych - Lubawka (direction Praga) and the section Czechowice Dziedzice - Zebrzydowice (Ostrava, Brno). For currently understandable reasons, the creators of the CPK concept omitted the cross-border section Poznań to the border with Germany (to Berlin), because passengers will not be transported from the CPK to Brandenburg Airport. On the other hand, a completely new project is the section Rzeszów - Sanok (direction Bucharest), although it seems that this is a project for the very distant future. In general, for projects of all cross-border sections, which generally generate negligible rail traffic, the prior construction of internal high-speed lines and bilateral coordination of investments with neighboring countries will always be an essential element.

Summary

Various concepts of building new high-speed railway lines have been discussed in economic, transportation, and scientific circles for many years and are generally accepted, although there are sometimes opposing voices. It seems that the currently adopted general concept of building Polish high-speed railways will be approved by most of these circles, and in the future also by the society, which is, after all, the beneficiary of new investments in the railway system. Due to the fact that the construction of new high-speed railway lines in 2022 has not yet started, it is possible to introduce some changes in the designs of the railway component, because some planned spatial and geographical layouts of new high-speed railway lines do not seem correct from the point of view of the already formed polycentric network of Polish

transport and the passenger streams occurring in it, conditioned by the transport activity of the Polish population. These changes should include, in particular, the spatial and geographical layout of the Warsaw-CPK-Łódź-Poznań/Wrocław HSR line and the HSR line called CMK North: STH-Płock-Włocławek-Tczew-Grudziądz-Gdańsk. The adopted variants of the routes of the above-mentioned lines are inconsistent with the National Spatial Development Concepts adopted in Poland in the past, as well as with some documents of the European Union (TEN-T network), the provisions of which were created at the request of the Polish authorities. At the same time, it is obvious that domestic or even international documents can always be changed and adapted to current concepts, while the shaped population movements generating passenger flows in specific relations should not change, but rather shift the demand towards more attractive forms of transport in terms of time and environment, in particular towards high-speed trains adapted to the needs of the population. The approach to the construction of new railway connections between the central airport and some cities, based on fragmentarily built and relatively short new sections of railway lines with a maximum speed of 200 km/h, also requires changes. This applies in particular to the connection of the STH with Koszalin and Rzeszów. In the latter case, a comprehensive connection via the HSR lines of the capital and the STH with Rzeszów via Lublin should be considered.

Source materials:

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