



The first high speed train in Poland ED250 (Pendolino). Photo. G. Kocłęga.

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## The role of Polish infrastructural projects in creating high speed railway network in Central Europe

*The projects of construction high speed lines in Poland have also international aspects. The lines planned in Poland are part of Trans-European network of high speed railways. In the newest version of CEF funds Polish project of HSL Warszawa-Lodz-Poznan/Wroclaw is part of corridor North Sea-Baltic Sea connecting high speed railways network in Germany and Baltic countries (planned on 2027). Project of high speed railways network based on, at least initial phase, on Warszawa-Lodz-Poznan/Wroclaw (Y) line and Warsaw-Katowice/Krakow (CMK) line, which is stated in UE documents as „double Y”, is key part of Trans-European Network, which connects high speed railway network of neighbour countries, allowing to create high speed system in Central Europe.*

Creating international system, including significant travel distance – even a few thousands kilometres, is a big challenge. It requires perspective planning of technical parameters and its routes within national transport priorities and achieve competitive time travels of international journeys to other means of transport. Economic efficiency of these projects is requirement of acquiring financial support.

Despite the numerous legislations of European Union's authorities, the process of creating high speed railway network in European Union has not achieved decent level yet. That issue

has been presented by European Court of Auditors in the newest report [2]. In Europe there is no sufficient cohesion of high speed railway network regarding technical parameters and there is lack of cross-border lines, which would connect neighbour countries. As a part of high speed railways project in Poland conceptual studies and analysis on possibilities and conditions of connecting Polish high speed railway network to European has been taken up. In this article has been presented analysis of the state of planning work of building new lines in Central Europe.

### Current railway market status in international connections

Polish status on international network connections from Poland to neighbour countries is very disadvantageous. Even connections between capitals, despite significant improvement and shortening time travels in the last years, are still very long. Connection Warsaw-Vienna takes 7 hours, Warsaw-Prague about 8 hours. Warsaw-Berlin takes 5 hours, what is barely acceptable for passengers. In this all connections business purpose is insignificant. International transport from other Polish cities is even worse. West Poland including Lodz, doesn't have direct railway connection with Prague or Vienna – only buses and a few air connections are available in public of public transport. Railway connections to Berlin are exist besides from Warsaw, only from Poznan (5 times per day), Gdansk and Bydgoszcz (once a day) and Szcze-

Tab. 1. Current status of realization of high speed railway projects in Poland

Investment	Current status	Priority
New high speed line Warsaw–Łódź–Poznań/Wrocław	Feasibility study finalised	Basic network, part of Northern Sea – Baltic Sea corridor
Modernization of Warsaw–Katowice/Krakow line to high speed parameters)	During partly realization (I stage 200 km/h)*	Basic network, part of Baltic Sea – Adriatic Sea corridor
Modernization of Łódź–Opoczno line (connection to CMK line)	Feasibility study finalised	Basic network
New high speed line Wrocław – boarder of the country – Prague	Prefeasibility study finalised	Comprehensive network
New high speed line Poznań–boarder of the country–Berlin	Prefeasibility study finalised	Comprehensive network, part of Northern Sea – Baltic Sea corridor
New high speed line Katowice – boarder of the country – Ostrava	Feasibility study finalised	Comprehensive network, part of Northern Sea – Baltic Sea corridor
New high speed line Elk – boarder of the country (stage of high speed line Rail Baltica)	No project	Comprehensive network, part of Northern Sea – Baltic Sea corridor

\* Feasibility study for high speed line parameters finalised in 2010, modernization to 300 km/h and connection to Katowice and Krakow.

cin (3 times per day). What is more at the weekends is available Wrocław–Berlin connection. Essential issue is lack of daily direct connections from Cracow, Katowice, Opole, Wrocław and Łódź.

Car is predominant means of transport of international journeys in Central Europe, complemented by bus and air connection [10].

### Target of international high speed connections as part of TEN-T network

#### EU Regulation 1315/2013

EU Regulation 1315/2013 is basic of creating the high speed railway network in Europe, in which has been defined Trans-European passenger and freight networks. High speed network

contains already existing lines and lines indicated for construction and modernization to required parameters. Implementation of the program has been defined into time stages:

- 1) **Comprehensive network** (horizon of realisation till 2050);
- 2) **Basic network** (horizon till 2030). Contains key parts of comprehensive network, necessary for strategic realization of Trans-European transport policy. It is splitted into passenger and freight networks;
- 3) **Priority corridors** are coordination method of creating the most important parts of basic network. Investments are divided into 7 years stages, by financial perspectives. Project of Regulation for financial perspective 2021-2027 was submitted by European Commission with financial support 30,5 billion euro [17].

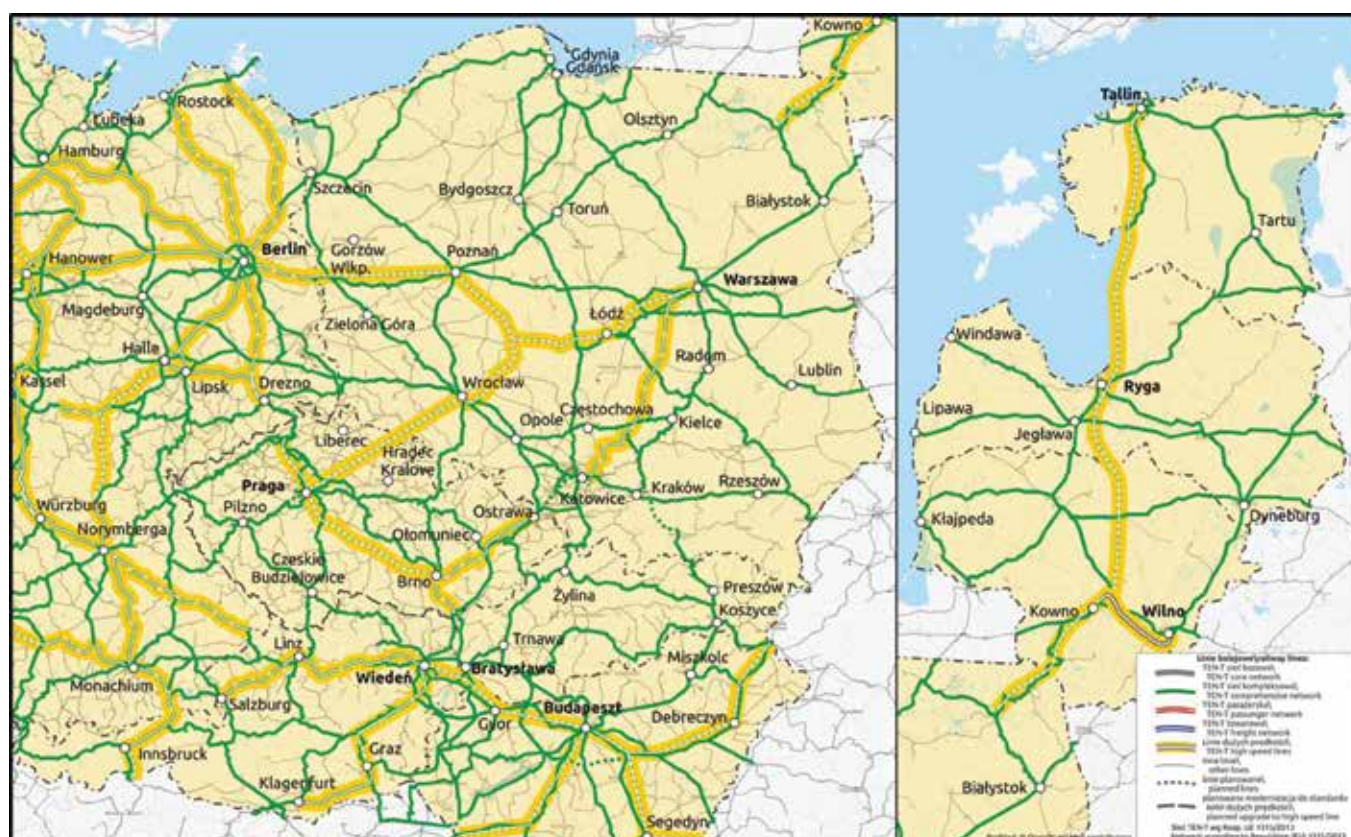


Fig. 1. High speed railway network in Central Europe on the background of TEN-T (UE Regulation 1315/2013). By Tomasz Bużalek



Fig. 2. Estimated time of travel from Warsaw to European cities, by high speed lines. By Tomasz Bużalek

**Poland**

In Poland has been designed following high speed railway lines:

- ♦ Warsaw-Lodz-Poznan/Wroclaw (Y);
- ♦ Warsaw-Katowice/Krakow (CMK);
- ♦ Poznan-border of the country (to Berlin);
- ♦ Wroclaw-border of the country (to Prague);
- ♦ Katowice-Ostrava;
- ♦ Elk-border of the country (to Tallinn).

Feasibility study and other analytic studies of these lines has been funded by European Union.

What is more, construction the high speed line Warsaw-Gdansk is part of the spatial development conception of Poland to 2030 [18]. The plans of creating the line as extension of CMK in northern direction, has been stated in 1970s [9]. In 2010 was created correction of the route, in order to connect more cities, for example Torun and create connection to Bydgoszcz and the middle Pomerania [9].

Study for high speed line Warsaw - eastern border of Poland as part of high speed line Moscow-Warsaw-Western Europe were prepared in 1990s [23].

**Czech Republic**

Study work of construction the high speed line has been done also in Czech Republic. Regulation for high speed program has been voted by Czech Parliament in 2017.

High speed railway network in Czech Republic is going to be developed in a few directions (Fig. 2) [16]:

- ♦ Dresden-Prague-Brno-Bratislava/Budapest/Vienna;
- ♦ Ostrava-Brno-Bratislava/Budapest/Vienna;
- ♦ Wroclaw-Prague-Munich.

Corridor Dresden-Vienna is planned to be completed firstly, containing Prague-Brno line, as a main part. Stages of Brno - border of the country following to Bratislava, Budapest and Vienna line are planned to be modernized to 200 km/h parameters. New high speed lines are planned to 300-350 km/h with opportunity of diversified passenger regional traffic.

**Lithuania, Latvia and Estonia**

Construction of high speed line - Rail Baltica with 1435 mm track - is key investment in Baltic countries. It is planned from Tallinn, via Riga and Kaunas to Polish/Lithuanian boarder (Trakiszki). The branch from Kaunas (airport) to Vilnius through airport (102 km) s planned as the new high speed line [19, 20].

New line is expected to be suitable for passengers and freight transport. Maximum speed for this line is set on 250 km/h.

Extension for section Tallinn-Helsinki is considered by building undersea tunnel. Feasibility study was completed in 2018. The tunnel is pre-planned to start after finishing Rail Baltica to Finnish - Swedish and Norwegian boarder is also considered [14, 15, 21].

**Slovakia**

There are no plans of construction high speed lines in Slovakia.

**Hungary**

High speed lines Vienna-Budapest-Bucharest and Budapest-Bratislava are planned in the frame of TEN-T network.

**Russia, Belarus**

As part of UIC studies, study of Asia-Europe high speed corridor, is being implemented. The line would go through China, Kazakhstan, Russia and Belarus to Polish border and connect to EU high speed network.

**Travel time from Polish cities to neighbour countries**

Estimation of travel time has been created on the basis of feasibilities studies. Scheme of chosen agglomeration connections by high speed and conventional lines has been presented in Fig. 2.

**Review of railway competitiveness in international transport in aspect of travel time**

Review of railway competitiveness in international transport should be relied on analysis of many factors, with time and cost of the travel as fundamental. Time and cost of travel are basic factors of choosing means of transport. Competitive time travel, in comparison to railway, may be only offered by air transport.

Bus or car travels are generally longer, but provide opportunity of door-to-door travel, however, that is not the important factor on long journeys. Organizing transport to station or airport is necessity in both railway and air transport. That analogy is such essential, that allows to create quite precise mathematic models of competitive conditions.

Comparison of high speed railway and air transport, in context, is connected with the offer of competitive means of transport. Travel time is widely consider in literature, with 3 hours and 1 hour 40 minutes, as boundary. High speed railway has essential role in these time intervals, taking over 60–90% all passengers. In case of achieving shorter travel time by railway, for example Warsaw–Berlin in about 3 hours long, it would be very competitive to air transport.

However, it is required to construction high speed line through the whole distance between these cities. Building high speed line in Poland and modernizing short stage, Frankfurt (Oder)–Berlin, would allow reaching travel time no longer than 3,5 hours, which might be competitive to air transport. Calculation of competitive means of transport shares in classic analysis is based on models of travel time, in which the shorter travel time, the larger share. The phenomenon is usually described by logit models (applicability is limitation in two-module terms only [24]) or nested logit taking into account more possibilities by determining the total probability of choosing j-th branch and i-th option on this branch [26]. Obviously there are multiple approaches of modelling, like probit model, logistic regression model, mixed models or developing heuristic models. However, all of them consist on defined influence factor (utility), which is usually travel time.

What is more, the models cannot be applied in all cases – they are suitable for local, but creating universal model is almost impossible. The main reasons are local conditions and geographically diversified mobility behaviours.

The other problem is calibrations of the model, which is based on study of passengers behaviours. Even though city or regional models are relatively easy (in context of data acquisition, for example KBR research), modelling passengers behaviours on longer distances is more complexed and expensive in

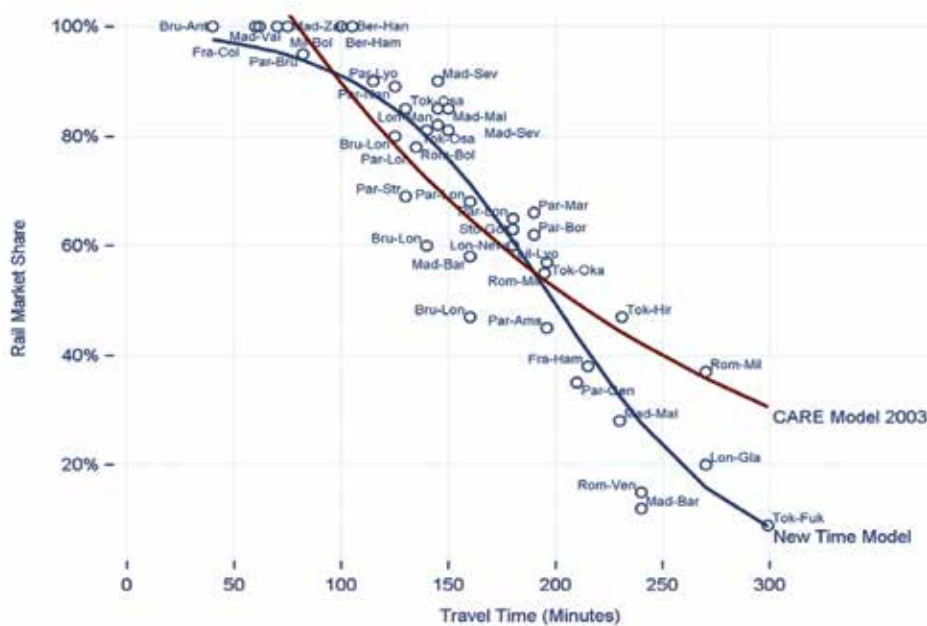


Fig. 3. Travel time and railway market shares in relation to air transport [12]

comparison to smaller areas. In that case is required to use calibration process based on analysis of the size of passenger flows in competitive transport branches [11].

Despite difficulties caused by local character of the models, attempt of creating common model, based on market share of railway and air transport on complexed connections as a function of time, has been taken up [15]. In order to improve the accuracy of mode, distance of travel factor, has been added.

$$U_{KDP} = \begin{cases} \frac{1}{1 + e^{-(4,4129+0,0018d-0,0264t)}} & t \geq 80 \\ \frac{1,415 - 0,006t}{100} & t \in (70,80) \\ 1 & t \leq 70 \end{cases} \quad [\%]$$

$U_{KDP}$  – share of high speed railway [%]

$t$  – travel time [min]

$d$  – distance [km]

Results of representative group of example journeys has been presented in the Fig 3. It contains comparison of older model (CARE Model 2003) and newer, more precise model (New Time Model).

This formula is characterized by a high compatibility to available data and due to [12] estimation error of high speed railway market share is -0,1% to 5,0%. What is more, the highest errors of analysis was in transport corridors in Italy (3,6% in average) and in Spain (1,8% in average) in the other countries error is marginal.

However taking into account only travel time is too simplified. Indeed, the results of research should be emphasized, if there is correlation [8, 3] but rely only on travel time may discourage passengers in case of any difficulties connected with chosen means of transport (time of reaching the airport, check-in time etc.). Because of that extended approach of the modelling process is being used, in order to take into consideration all factors, that influence the chain of travel – general travel cost [5]. It allows to take into account difficulties of competitive means of transport and to consider into summary all possible difficulties. General cost contains all stages of travel: reaching the station/

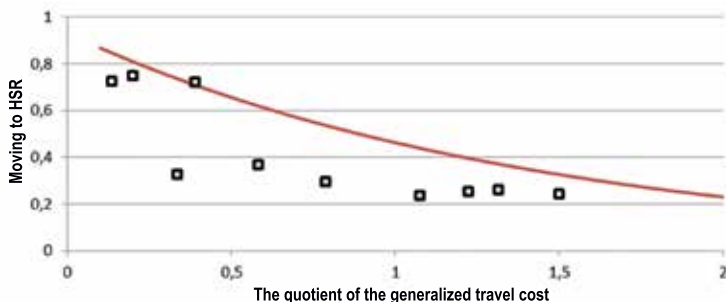


Fig. 4. Function of moving passengers from air transport to high speed railways [7]

airport time, waiting/check-in time, travel/flight and reaching the travel destination. This values are presented as financial equivalent, what clarifies the comparison. In the Fig. 4 has been presented taking over competitive air passenger by high speed railways ,as ratio function of general travel cost by this means of transport.

Of course in this situation is necessary to consider road transport, as the most flexible means of transport. As a result are available a competitive transport opportunities, and is required to split passengers between offered transport.

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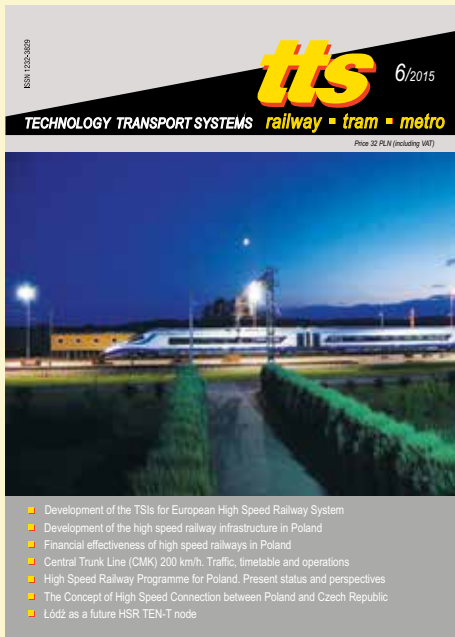
In 2011-2014 Director responsible for strategy and development including rolling stock and interoperability in PKP Intercity.



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