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Will High-Speed Rail revolutionise transport in Poland? What are the prospects for the development of Poland's railway system in the face of the energy crisis? Is the CPK project a genuine opportunity for the growth of the Łódź region? And what does Poland's journey towards high-speed rail look like? This issue also features a summary of the Event of the Year 2024 in High-Speed Rail—the International Scientific and Technical Conference 'High-Speed Railway Development in Poland – HSR PL 2024'—along with a collection of insightful articles on the advancement of high-speed rail. All this and more can be found in this year's edition of 'Przegląd Komunikacyjny'.


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Dear Readers

Many of us ask ourselves whether high-speed railways are just an engineers dream or a real need of modern civilization?

From the point of view of the ambitions and aspirations of engineers, high-speed railways are often the realization of passions and challenges related to the creation of modern technologies. In this case, the construction of transport systems requires the use of advanced tools and huge investments in infrastructure, which effectively stimulates the economy in the country. The development of the High-Speed Railway allows for testing record-breaking achievements and expanding technological boundaries through the use of innovative materials for the industry, designing appropriate railway geometry, using new traction power supply systems and solutions for railway control systems and rolling stock. In this sense, High-Speed Rail can be considered as a dream for engineers who are working on creating the transport of the future.

On the other hand, High-Speed Railways also have the potential to become part of modern transport systems. As population grows, sustainable development becomes a key goal and the need for efficient and environmentally friendly transport allows for the development of regions through which transport takes place. In particular, HSR is a response to problems related to traffic jams, air pollution and the rising costs of fossil fuels. Compared to road or air transport, High-Speed trains generate lower carbon dioxide emissions per passenger. Another advantage is energy efficiency, especially over long distances.

For the full effectiveness of the implementation of High-Speed Rail, it is necessary to ensure full accessibility to the services provided, including access to and from railway stations, because high-speed rail should be viewed from a broader perspective of the passenger and not just the railway line. In this case, Europe is a major beneficiary of the construction of High-Speed Rail, which has the potential to become an integral part of global transport networks, especially within the entire Schengen area.

Further development of the railway network faces cost challenges as well as the need to adapt the transport system to local realities. High-speed rail can therefore become the standard, but this requires extensive international cooperation and appropriate policies to support infrastructure development. The above issues were the main goal of the HSR-2024 conference, during which the engineering challenges and experiences from the operation of high-speed railways were presented to all participants of the first conference in Poland devoted entirely to the issues of high-speed railway construction. To be continued soon during the international railway fair TRAKO–2025.

Jacek Paś
Association of Engineers and Technicians of Communication RP

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International Scientific and Technical Conference 'Development of High-Speed Rail in Poland' – High Speed Railway Poland 2024 (HSR PL 2024)

Roman Góralski

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Accelerating High-Speed Rail in Poland and Europe

'This meeting is of historical significance—I am convinced of it.' – Prof. Janusz Dyduch, Honorary President of the Polish Association of Engineers & Technicians of Transportation (SITK RP)

'This is not just an ordinary conference; it is a step forward in integrating communities involved in the development of high-speed rail.' – Dariusz Klimczak, Minister of Infrastructure

'The discussions held here will lead to concrete solutions that will contribute to the development of high-speed rail and greater integration of our continent.' – Alan Beroud, DSc, Eng., President of the Management Board, PKP S.A.

'For the first time in Łódź, we are discussing visionary matters, which are essential to each and every one of us.' – Hanna Zdanowska, Mayor of Łódź

The ceremonial inauguration of the International Conference 'Development of High-Speed Rail in Poland' at the Andel's Hotel in Łódź, organised by the Association of Engineers & Technicians of Transportation of the Republic of Poland (SITK RP), took place on 28-30 October 2024. However, the legacy of these already historic discussions can still be seen in many segments of the industry today. And it is no surprise.

'This debate will serve as a foundation for further and better cooperation between those who plan the development of rail from a political perspective, those who organise transport services, those who construct and modernise railway lines, and those who engage with this field from a scientific standpoint.' – Minister Klimczak emphasised during the inauguration.

Jacek Paś, DSc, Eng., President of the Polish Association of Engineers & Technicians of Transportation, spoke in the same spirit: 'Our conference is a response to the need for information exchange within the high-speed rail community: railway industry specialists, scientists, local government officials, politicians, rolling stock manufacturers, infrastructure component producers, and construction contractors.'

It must be said that the proceedings at the Andel's Hotel in Łódź attracted enormous interest from those involved in high-speed rail development. Among the well over three hundred participants, practically all key decision-makers in this sector were present: representatives of the government and the European Parliament, executives of the largest Polish and European companies in the industry, leaders of international railway organisations, distinguished academics, and experts.

Beyond the participation of key representatives from the Polish government and the most influential figures in the national railway market, the significance

1. Opening of the HSR PL 2024 conference – President of SITK RP, Jacek Paś

2. Opening speech of the conference – Minister of Infrastructure, Dariusz Klimczak

3. Speeches by Honourable Guests – Member of Parliament, Dariusz Joński, European Parliament

4. Speeches by Honourable Guests – President of the Management Board of PKP SA, Alan Beroud

***5**. Speeches by Honourable Guests – Mayor of Łódź, Hanna Zdanowska*

***6**. Speeches by Honourable Guests – Director of the Railway Institute, Andrzej Massel*

of this conference is best reflected in the presence of distinguished international guests. These included Francois Davenne, Director General of the International Union of Railways (UIC); Dr Alberto Mazzola, Executive Director of the Community of European Railways and Infrastructure Managers (CER); Enno Wiebe, Director General of the Union of European Railway Industries (UNIFE); as well as Kristian Schmidt, representative of the Directorate-General for Mobility and Transport (DG MOVE) of the European Commission; Dariush Kowsar, Director for European Affairs at SNCF Réseau; Vytis Zalimas, Chief Executive Officer of AB LTG Infra; and many others.

A Civilisational Leap

Significant declarations were made right at the outset of the conference. Dariusz Joński, a member of the European Parliament's Committee on Transport and Tourism, assured that the construction of high-speed rail in Poland is the most important infrastructure project for Donald Tusk's government. Moreover, he confirmed that Apostolos Dzidzikostas, at the time still a candidate and now European Commissioner for Sustainable Transport and Tourism, is determined to ensure that high-speed rail investments in Poland come to fruition. The MEP also expressed his conviction that the realisation of Minister Klimczak's idea—linking Berlin with Kyiv via Łódź and Warsaw by high-speed rail—seems feasible and possible to implement within this parliamentary term, or at the very least, to make significant progress on it.

Filip Czernicki, President of the Management Board of CPK, emphasised that the era of ideology-driven planning and drawing routes on maps with markers is over. Today, all CPK investments are thoroughly analysed, calculated, and reviewed with the best experts in the industry: 'including yourselves,' he stated, while encouraging participants to consult with company representatives who were present throughout the conference. Maciej Kaczorek, Vice President of PKP Polskie Linie Kolejowe, highlighted that breaking the 200 km/h speed barrier on Polish railways marks another civilisational leap for the country—whether 250 km/h on the Central Railway Main Line or the 'Y' high-speed rail line from Warsaw to Łódź and Poznań, with speeds exceeding 250 km/h.

Challenges ahead, but…

'High-speed rail was made for Poland, considering the shape of our country, the distance from the administrative centre, and the rising railway passenger statistics, which for the first time exceeded 100 million in a single quarter,' argued Kamil Wilde, Vice President of the Office of Rail Transport (UTK). He admitted that the challenges are countless, mainly technical (though not exclusively), including the adaptation of existing railway infrastructure and the construction of new lines designed for speeds never before seen in Poland. However, Wilde had no doubt that Poland is capable of overcoming these challenges, citing the French TGV, which has been operating successfully for 40 years, as an example. An optimistic statement was also made by Minister Piotr Malepszak, who spoke 'as an engineer, not a politician.' He stated that within three years, it will be possible to travel at 250 km/h on the main railway corridor, and within ten years, an entirely new high-speed rail line built from scratch will be operational (we'll hold you to that—editor's note).

Dr Alberto Mazzola, Executive Director of the Community of European Railways (CER), assured that the development of HSR in Poland is not only crucial for domestic transport but also for the functioning of the entire European network. He also presented the European high-speed rail expansion plan, under which the current 11,666 km of HSR lines is expected to increase by 21,000 km between 2030 and 2050. This expansion will allow 60% of the EU population to have access to high-speed rail and ensure a 50% market share in passenger transport.

High-speed rail in Poland

The first and most important panel on the future of high-speed rail in Poland was moderated by Dr Eng. Jacek Paś, President of SITK RP, and Dr Jakub Majewski, Chairman of the Supervisory Board of PKP Polskie Linie Kolejowe. The discussion panel was opened by a speech from Piotr Malepszak, Undersecretary of State at the Ministry of Infrastructure responsible for rail transport. Among the distinguished panel participants were: Alan Beroud, DSc, Eng., President of the Management Board of PKP and Chairman of the International Union of Railways (UIC), Francois Davenne, Director General of UIC, Dr Alberto Mazzola, Executive Director of CER, Enno Wiebe, Director General of UNIFE, and Kristian Schmidt, European Commission, Directorate-General for Mobility and Transport (DG MOVE), who participated remotely.

All panellists—leaders in European rail transport—expressed unanimous support for the rapid development of high-speed rail (HSR) in Poland and the entire region. Among the many benefits of this major project, they particularly emphasised the improved integration and enhanced communication between EU citizens. As an example, they pointed out that once the high-speed rail line between Berlin and Warsaw is completed, it will be possible to travel between the two capitals for a business lunch and return the same evening. PKP President Alan Beroud

7. Discussion Panel: 'High-Speed Rail for Poland'

8. Discussion Panel: 'PKP PLK and CPK investments are an opportunity for the development of Łódź and Central Poland'

asked Kristian Schmidt (DG MOVE) about European funding for these ambitious plans, referring to their previous discussion in Berlin. While no concrete details were provided this time, the strong ecological, economic, social, and safety arguments in favour of accelerating HSR development make the future of the project seem secure.

A development opportunity for Łódź

A particularly important panel, both at the conference venue and beyond, titled 'PKP PLK and CPK investments are an opportunity for the development of Łódź and Central Poland,' was moderated by Wawrzyniec Wychowański, DSc, Eng., Secretary General of SITK RP, and Zbigniew Szafrański, Chairman of the Supervisory Board of Centralny Port Komunikacyjny (CPK). The panel opened with Szafrański's presentation, titled 'Why does Łódź need an underground station and tunnels beneath the city centre?,' which set the stage for a debate featuring: Piotr Rachwalski, Member of the Management Board of CPK, Adam Pustelnik, First Deputy Mayor of Łódź, Maciej Kaczorek, DSc, Eng., Member of the Management Board of PKP PLK, Maciej Sobieraj, President of the Management Board of Łódź Agglomeration Railway, Michał Wolański DSc, Professor at SGH. All participants in the discussion emphasised the crucial role of high-speed rail (HSR) in the further development of Łódź and the entire Łódź region.

President Rachwalski pointed out that the planned 'Y'-shaped HSR line will connect four of Poland's five largest cities, with Łódź located at its centre. As a result, the former capital of the textile industry will gain significantly faster connections not only to Wrocław, Poznań, and Warsaw but also to Białystok, Lublin, Szczecin, Berlin, and Zielona Góra via modernised PKP PLK lines. The ability to cover these distances in one to two hours opens entirely new investment opportunities and growth prospects. Speakers also addressed Łódź's proximity to Warsaw, which for many years hindered the city's development by drawing away its most highly skilled professionals and investment. However, this proximity is now becoming a major advantage. With a train journey of just over half an hour, it will soon be possible to have an office in Warsaw and a warehouse in Łódź, live in Łódź while working or studying in Warsaw. 'The emergence of the long-discussed Warsaw–Łódź duopolis will create completely new opportunities for Łódź,' stressed Deputy Mayor Adam Pustelnik. Meanwhile, PKP PLK President Maciej Kaczorek highlighted the benefits of integrating urban and regional transport with long-distance rail. This coordination will provide Łódź with a fast and reliable transport system, enhancing connectivity within the city and beyond.

Speed also integrates

The panel 'The role of high-speed rail as an element of the TEN-T network in the development of an integrated European railway system' was moderated by Mariusz Buława, DSc, Eng., President of the Management Board of Voestalpine Signalling Poland, and Andrzej Massel, DSc, Eng., Director of the Railway Institute.

The debate was opened by a keynote speech from Piotr Wyborski, President of the Management Board of PKP PLK SA, who also participated in the discussion alongside: Vytis Zalimas, LTG Infra, Zbigniew Szafrański, CPK, Marius Narmontas, COO of Rail Baltica AS, Dariush Kowsar, SNCF Réseau, and Radek Čech, Správa Železnic. The highly engaging discussion, which merits a separate analysis, highlighted that although there is a general consensus that high-speed rail is an extremely useful mode of transport contributing to the achievement of many EU sustainable mobility goals, and that investments in this area co-financed by EU funds could bring significant benefits, a solid, unified approach at the EU level is still lacking.

Complementary services

If the conference aimed to serve as a platform for exchanging information among specialists from various fields related to high-speed rail (HSR), then the panel 'Complementary services for the high-speed rail system' was a perfect example of this objective. The discussion brought together representatives from local governments, manufacturers, railway operators, and infrastructure managers. It was moderated by Tomasz Lachowicz, Director of the PKP SA Representative Office in Brussels, NATO TG IST – Senior Transport Advisor, and Wawrzyniec Wychowański, DSc, Eng., Secretary General of SITK RP.

The panel opened with a keynote speech by Alan Beroud, DSc, Eng., President of the Management Board of PKP SA, who emphasised the crucial role of complementary services—alongside railway infrastructure—in ensuring a convenient, fast, and integrated transport system.

The speakers unanimously agreed on the importance of intermodal hubs in cities, where rail connects with public transport, airports, road transport, and, in some cases, water transport. Katarzyna Strzegowska, Director of the Warsaw Public Transport Authority, even put forward the bold claim that HSR will neither function properly nor develop without continuous cooperation with urban transport. Her view was reinforced by Janusz Malinowski, President of PKP Intercity, who stressed the importance of ticketing systems that should enable passengers to travel seamlessly from their doorstep to their workplace or any other destination.

The panel also brought a surprise, which turned out to be a perfect conclusion to the discussion—the signing of

9. Discussion Panel: 'The role of high-speed rail as an element of the TEN-T network in the development of an integrated European railway system'

10. Discussion Panel: 'Complementary services for the High-Speed Rail system'

a letter of intent between the presidents of PKP Intercity and Warsaw's Public Transport Authority (ZTM) regarding a new offer for PKP Intercity passengers. Under this agreement, an Intercity train ticket will also grant access to Warsaw's public transport system.

'In my opinion, this is a small step towards a great success,' summed up President Beroud, who played a significant role in facilitating the agreement.

The panel featured the participation of: Andrzej Bułczyński, Member of the Management Board of PKP SA, Janusz Malinowski, President of the Management Board of PKP Intercity SA, Katarzyna Strzegowska, Director of the Warsaw Public Transport Authority (ZTM), Bartłomiej Zgorzelski, Social Representative of the Mayor of Łódź for Development and Entrepreneurship Support, Artur Fryczkowski, Vice President of Alstom Poland, Cezary Lis, Segment Manager for HITACHI ENERGY Transportation, and Krzysztof Zdziarski, President of the Management Board of PESA Bydgoszcz.

Time for technology and procedures

A particularly valuable component of the conference—and a true crème de la crème for the engineers, technicians, and managers in attendance—were the outstanding presentations. While it is unfortunately impossible to mention, let alone discuss, all of them in this report, those interested can easily find them in the programme on the SITK RP National Board website (https://www.sitkrp.org.pl/).

It must be said that all the presentations—from Engineering structures along high-speed railways in Poland, delivered by Grzegorz Piotrowski, Director of the Railway Division at CPK, and Railway tunnels for high-speed railways in CPK railway standards, presented by Jolanta Radziszewska-Wolińska, DSc, Eng., to Turnout system in digital railways, introduced by Mariusz Buława, DSc, Eng., from Voestalpine Signaling Poland, and Time, money, safety – a new approach to railway traffic control tenders, by Tomasz Pałaszewski from Hitachi Rail GTS Polska Sp. z o.o.—offered intriguing insights into new solutions in this field.

To this list, we should add presentations by PESA Bydgoszcz SA, ALSTOM, KOMBUD GROUP SA, BUDIMEX SA, PORR SA, GÜLERMAK, KELLER Polska, HERRENKNECHT AG, as well as the Railway Institute, PKP SA, PKP PLK, PKP Intercity, and the Public Procurement Law Association. This gives only a preliminary glimpse into the broad thematic range of these talks. It is no surprise that they turned out to be a real draw for specialists from various fields, who participated in large numbers and engaged in discussions both during and after the presentations.

On the third day of the conference, participants took part in a technical site visit to the construction site managed by Centralny Port Komunikacyjny (CPK). During the visit, they were introduced to the ongoing foundation reinforcement project for the Łódź Cultural Centre (ŁDK) in the vicinity of the Łódź Fabryczna chamber. The technical patron of the event was Keller Polska, the contractor responsible for the construction works. Keller's experts provided a detailed overview of the challenges associated with the project, discussing both the difficulties of working within a dense urban environment and the specific technological solutions that enabled the effective reinforcement of the ŁDK foundations. Participants travelled to the site by tram-bus, and the opportunity to closely observe specialised foundation works was a valuable experience for all involved. A special thanks goes to the Łódź branch of SITK, which played a key role in organising the event, ensuring its logistics and smooth execution.

The organisation of the conference would not have been possible without the invaluable support of our Partners, to whom we extend our heartfelt thanks for their contribution and assistance in making this event a success. Special appreciation goes to our general partners – Voestalpine and Hitachi, whose support played a key role in ensuring the success of the conference. We also express our gratitude to our gold partners—Alstom, Kombud Group, Pesa Bydgoszcz, Budimex, Gulermak, Keller Polska, Porr, and Tines—whose engagement significantly contributed to the event's development and high level of expertise. A sincere thank you also goes to our partners—Elektroline, PKP Intercity, Polregio, Siemens Energy, and TracTec—for their support and dedication.

We greatly appreciate our media patrons—ISB News, TVP 3 Łódź, and Sektor Kolejowy, who helped deliver information about the event to a wider audience and contributed to promoting key topics discussed during the conference. Thanks to the commitment of all partners and patrons, last year's event became a valuable platform for the exchange of knowledge and experience, for which we are deeply grateful.

We are thrilled to announce that the next edition of the HSR PL 2025 conference will take place in a unique setting—during the TRAKO fair, the largest and most important railway industry event in Poland and one of the key gatherings in Europe. This will be a fantastic opportunity to combine discussions on modern rail transport solutions with the presentation of the latest technologies and innovations in the sector.

We warmly invite you to participate in HSR PL 2025 – TRAKO edition. Details on the programme and registration will be announced soon!

Dariusz Klimczak

Minister of Infrastructure

A step forward…

I would like to express my sincere appreciation for this initiative. This is not just an ordinary conference—it is a step forward in integrating the various sectors involved in the development of high-speed rail. I hope this conference will serve as a foundation for continued, lasting, and improved cooperation between those who plan railway development from a political perspective, those who organise rail transport, those who build and modernise railway lines to make them as attractive as possible for passengers, and those who contribute to the scientific advancement of rail transport. I am grateful to everyone who has recognised the need for this integration because, in Poland, we have talked too much about building High-Speed Rail and achieved far too little so far.

Now, acceleration is necessary.

Present here at this conference are not only my colleagues from the ministry but also representatives of affiliated entities and companies that work with us daily. To the organisers, I would like to say: today, the best of the best have gathered—those who personally manage these companies, as well as those leading the most critical projects—because we are facing a tremendous challenge. In the past, there were times when companies met in courtrooms instead of on construction sites. Today, we are sitting at the same table, and I am pleased that we can engage in discussions with everyone who is committed to the development of this sector and this vital part of the Polish economy.

I am particularly pleased that not only contractors are here but also representatives of the European Commission and international European organisations. It is crucial that we align our plans with the European Union's multiannual financial framework. Without proper planning, strategy, and—above all—funding, we cannot implement these plans as quickly as both passengers and those responsible for transport development would like.

I hope that together, with contractors, transport organisers, and experts in the scientific development of Polish transport and railways, we will be able to achieve this as soon as possible.

Today, Łódź is the heart of the High-Speed Rail project.

The statement comes from the conference opening speech.

Dariusz Joński

European Parliament Committee on Transport and Tourism

I would like to express my appreciation for this extremely important meeting because here in Łódź, in our city, the key ambassadors of the High-Speed Rail project have gathered. And I want to say that this is not some distant vision of the future. This is something that is already being implemented because the exit chamber for the High-Speed Rail is currently under construction. And it is on schedule. And on time. And the funds are there.

But, of course, the most important part is still ahead of us. In the new financial perspective, we have a great opportunity to secure funding for this, one of the most important infrastructure projects. I would even dare to say that, after the motorway construction programme that began 15 years ago, this will be the next great civilisational leap for Poland. It is possible, and it is entirely realistic. For Prime Minister Donald Tusk's government, this is the most important infrastructure task.

For my part, I want to say that I will do everything to ensure that we secure funding for High-Speed Rail and build it on time, because the timeline is crucial—we have a lot to catch up on.

The statement comes from the conference opening speech.

Eng. Alan Beroud, PhD

President of the Management Board
Polskie Linie Kolejowe S.A.
(Polish State Railways)

The 'High-Speed Railway Development in Poland' conference in Łódź was an extremely significant event for the entire railway sector. It provided a platform for the exchange of knowledge and experience regarding the implementation of High-Speed Rail systems, both in a national and international context.

During the meeting, we discussed the key challenges and opportunities arising from climate change and the growing demand for passenger and freight transport. Particular attention was given to the integration of the Polish railway network with European railway infrastructure, in line with the European Union's climate policy guidelines.

We also addressed the issue of financing the necessary processes for railway modernisation and expansion. This challenge requires a strategic approach and responsible planning in order to create a modern transport system that meets future demands and serves as a foundation for sustainable development.

It is worth emphasising that such events not only facilitate the exchange of views but also contribute to building a shared vision for European rail transport. The word 'responsibility'—particularly in terms of climate—resonated strongly throughout the conference as a key driver of our actions. Rail, as the most environmentally friendly mode of transport, can and should play a crucial role in the transformation of the European transport market.

I am convinced that the conclusions and insights gained from this conference will be a valuable contribution to the development of a modern, integrated, and environmentally friendly railway system in Poland and Europe.

Piotr Wyborski

President of the Management Board
Polskie Linie Kolejowe S.A.
(Polish State Railways)

I would like to take this opportunity to extend my congratulations to the organisers of the International Scientific and Technical Conference 'High-Speed Railway Development in Poland'—the Association of Engineers and Technicians of Communication of the Republic of Poland—for hosting such an important event for the railway sector.

During the discussion panel, which was sponsored and organised by PKP Polskie Linie Kolejowe S.A., I had the opportunity to speak with representatives of European railways where high-speed rail has been in operation for decades. The exchange of knowledge and drawing on international experience is of great importance to us, and the adaptation of proven European solutions can support Poland's plans for the development of high-speed rail, particularly in balancing infrastructure development for regional transport with investments in high-speed rail lines.

The current projects being carried out by both PKP Polskie Linie Kolejowe S.A. and CPK aim to provide the best possible fast connections, not only between countries in the region but also between interregional and metropolitan areas. This will contribute to the further development of an integrated European railway network.

The discussion panels and the topics addressed sparked great interest among attendees, and specific issues led to lively discussions, demonstrating just how socially significant and engaging this subject is.

Given the strong interest in the conference and the large audience it attracted, I hope it will become a permanent fixture in the calendar of events dedicated to the development of high-speed rail. I also hope it will evolve into a recurring event where we can track the progress of high-speed rail development in Poland year after year and continue sharing experiences with our international partners.

Katarzyna Strzegowska

Director
Public Transport Authority (ZTM) in Warsaw

The conference's central theme is of great importance to the transport industry, as high-speed rail represents the future. Passengers expect not only ever-higher standards from operators but, above all, shorter journey times.

This is undoubtedly a major challenge for everyone involved in transport in Poland, yet it is an absolute necessity, as high-speed rail is already the standard in Europe—and we must keep pace with the best. I am very pleased that discussions on this matter are taking place and that we have the opportunity to participate in them. The introduction of high-speed rail will also have an impact on local transport, particularly in Warsaw, which serves as a major transport hub. This brings many opportunities but also challenges. From the perspective of a public transport organiser, service complementarity and cooperation across multiple areas are crucial. Firstly, there is the integration of fares and ticketing. Secondly, information integration—for example, the creation of a unified application allowing passengers to plan their journeys at every stage, as well as the standardisation of passenger information at stations and stops. Another key issue is the so-called 'last mile'. Here, cooperation is essential to ensure the best possible connections between urban transport and railway stations. Of course, the introduction of high-speed rail also presents challenges that we must address. For Warsaw, one of the most pressing issues is railway infrastructure capacity, which is already nearing its limits. Long-distance trains—including high-speed services—are a priority on the tracks, but this must not come at the expense of passengers using local rail services, who make up a significant portion of the metropolitan area's commuters.

This is why substantive discussions and the integration of various stakeholders are essential for such significant investments. They provide an opportunity to exchange views, experiences, and information, ensuring thorough preparation for the implementation of such a large-scale project.

Zbigniew Szafrański

Chairman of the Supervisory Board
Central Communication Port (CPK)

The conference 'High-Speed Railway Development in Poland' was, in my view, crucial in promoting high-speed rail (HSR) in Poland for three reasons. The first day of the conference, which we might call the 'political-strategic' day, demonstrated that there is a strong commitment in our country to undertake this task, and that our international partners consider this project to be highly significant—not only in terms of Poland's sustainable transport development but also as an integral part of the TEN-T network in Central and Eastern Europe. The efficient construction of Poland's motorway network is proof that we are capable of delivering large-scale infrastructure projects. Now, it is time for the railway sector.

The following two days, dedicated to technical issues, highlighted the immense challenge of constructing railway lines with technical and operational parameters previously unknown in the Polish rail network. And while advocates of initiatives such as 'Yes to CPK' may be adept at trivialising the subject, engineers and technicians are well aware of the tasks ahead. Meanwhile, company presentations demonstrated that businesses are prepared to take on this challenge, seeing it above all as an opportunity for technological advancement.

And finally, the city of Łódź and the central region of Poland. The construction of a national airport 'next door' alongside the HSR line represents a tremendous development opportunity—provided that potential beneficiaries prepare adequately to take full advantage of it, a point that speakers and panellists sought to impress upon local authorities.

I would like to see the 'High-Speed Railway Development in Poland' conference organised regularly—perhaps every two years. It would serve as an excellent opportunity to present progress on the project and would provide companies with a forum to showcase the technical and technological solutions implemented in this project, which is crucial to the development of transport in Poland.

Adam Pustelnik

First Deputy Mayor of the City of Łódź
Łódź City Hall

The International Scientific and Technical Conference 'High-Speed Railway Development in Poland' can be considered a key event for the future of railway transport in Poland, with particular significance for Łódź and the Łódź Voivodeship.

The conference highlighted Łódź's strategic role in the planned High-Speed Rail (HSR) system, which is fundamental to the economic development of the city and the region. The HSR project, with the Warsaw–Łódź line as a key component, is set to be a catalyst for economic and social transformation.

For Łódź's business sector, the project opens up new development prospects. The significant reduction in travel time to Warsaw will fundamentally reshape business relations, enhancing access to the Warsaw job market and capital resources. Łódź has the potential to become a hub for innovation and research in railway technologies, attracting new investments in high-tech industries.

For the Łódź Voivodeship, the HSR project signifies a transformation of economic and spatial structures. New connections will enhance mobility for residents and open up the region to new markets. The planned connection with the Central Communication Port (CPK) will establish the voivodeship as a key transport hub.

HSR will have a significant impact on the labour market, facilitating easier commuting between cities. For Łódź, this means the potential influx of highly skilled professionals. The project is also expected to contribute to the revitalisation of urban areas and stimulate the development of modern districts.

The conference underscored the importance of integrating HSR with the existing infrastructure. Investments such as the Łódź cross-city tunnel are crucial to maximising the benefits. The HSR project could become a driving force for innovation and technological development in the region.

Thus, the conference can be seen as a catalyst for discussion on the future of railway transport and its impact on regional development. For Łódź and the Łódź Voivodeship, High-Speed Rail presents an opportunity for profound economic and social transformation, potentially establishing Łódź as a modern and dynamically developing urban centre.

Perspectives for the development of the Polish railway transport sector in the face of the energy crisis: A critical analysis

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Abstract: The authors of the article Perspectives for development of the Polish Railway Transport Sector in the Face of the Energy Crisis: A Critical Analysis have concentrated their efforts on presenting essential information and issues concerning both the current state of railway transport and its future prospects. This has been outlined in the context of the escalating energy crisis, a result of various factors often beyond the control of countries that import energy resources and electricity. According to the authors, particular attention should be paid to short- and medium-term problems arising from the Russian aggression towards Ukraine, as well as to challenges that are paradoxically much harder to resolve—those linked to the European Union's implementation of programs aimed at achieving broadly defined climate neutrality.

Keywords: *Rail transport; Climate neutrality; Energy*

Introduction

The earliest attempts to utilise the potential of railway transport date back to antiquity, when makeshift wagons carrying materials necessary for the construction of pyramids and temples moved along grooves in the ground or wooden beams. The driving force behind these vehicles was provided by horses or oxen, and at times, even by human effort. Around 600 BC, the Greeks constructed a near 8.5-kilometre-long proto-railway (Diolkos), which was used to transport ships across the Corinth Canal. The significance of this investment is evidenced by the fact that it remained in use for the next 600 years [1]. The first railway system resembling today's technical solutions was used for transporting coal from the coal basin in Darlington to the port in Stockton. This event took place on 27 October 1825 in Britain, an empire that was then a global power, its strength founded on innovative production solutions. It was the British who began large-scale coal production to utilise this resource as an energy carrier. Energy was the driving force behind industry, enabling the transition from the age of manufactories to the era of machine-based production. All of this required a reliable energy source. As the brilliant inventor, pioneer, and builder of the first railway, George Stephenson, recalled: '*Initially, I formulated the principle of a strict connection between the track and the locomotive, designing rails that could withstand the dynamic impact of locomotive wheels without any risk. I convinced the management of the benefits of applying my ideas and obtained permission for the experimental introduction of the locomotive as a driving force, but this revolutionary technical innovation still required parliamentary approval. I obtained it in 1823*' [2].

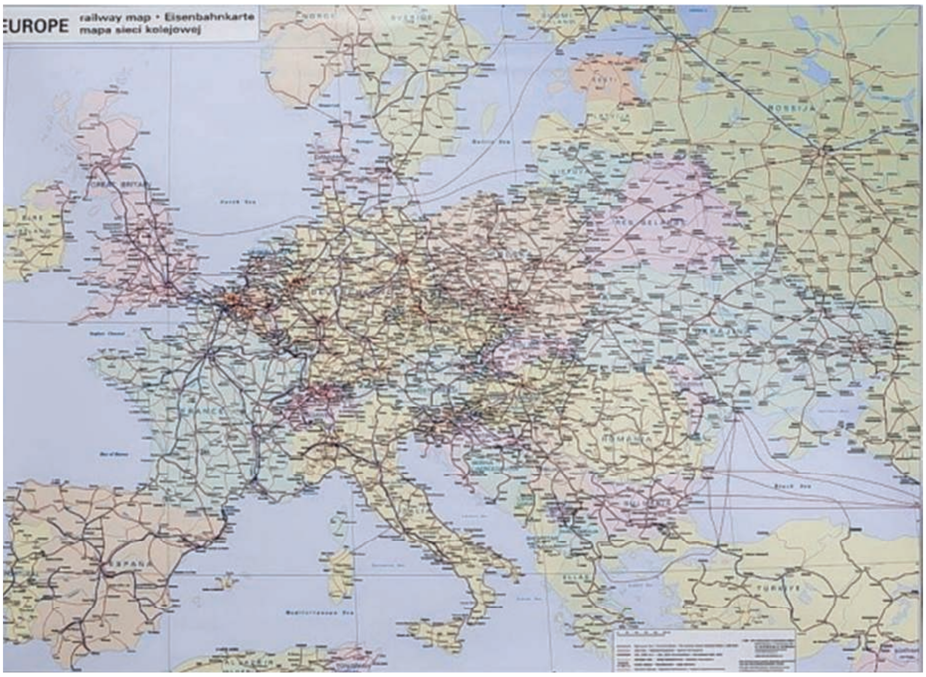
The geopolitical situation the world has been facing for several years now is compelling decision-makers across multiple levels—political, economic, and social—to undertake a profound redefinition of the concept of security assurance and resilience-building, both in highly developed countries and in those seeking to join the ranks of advanced organisations through alliances or, at times, aggression. It must be acknowledged that alongside military, climatic, or pandemic-related threats, other significant disruptions to societal functioning may arise in the near future, the nature and scope of which remain unpredictable at present. These disruptions may be minor and localised or assume a catastrophic global scale. Among the serious threats whose early signs are already clearly visible, one can include uncontrolled migration between the Global South and North, as well as the risk of limited access to both energy resources and energy itself.

As events of recent years have demonstrated, transport and connectivity constitute fundamental components of ensuring overall security. Although connectivity does not form the primary subject of this analysis, in an era of digitalisation and automation, it is intrinsically linked to transport-related considerations. Alongside connectivity, another critical factor influencing the operational readiness of transport organisations is the assurance of their driving force—energy.

The development of global transport networks has driven, and continues to drive, the expansion of railway infrastructure. Wherever 'the tracks reached,' centres of growth emerged, new metropolitan and industrial hubs were established, along with the necessary infrastructure to support them. The notion that 'civilisation arrived with the railway' has transcended academic discourse, becoming a widely accepted truth. Despite the passage of time, this remains the case. Even with the advancement of other modes of transport, the railway continues to hold a dominant position. Without directly linking security considerations to 'competitiveness,' one could argue that the main 'rival' of rail transport at present is road transport, particularly over shorter distances. When looking at longer routes, rail continues to compete with air travel in passenger transport and with maritime transport, particularly in intercontinental freight connections. Although underfunding of railway infrastructure and the resulting capacity limitations remain a global challenge, it is important to recognise that, unlike road transport, trains, though they may experience delays, do not face congestion—an undeniable advantage in the competition between rail and road transport. Another equally significant factor advocating for the use of rail as the primary mode of freight transport is its strategic role in the broader sphere of national defence and security.

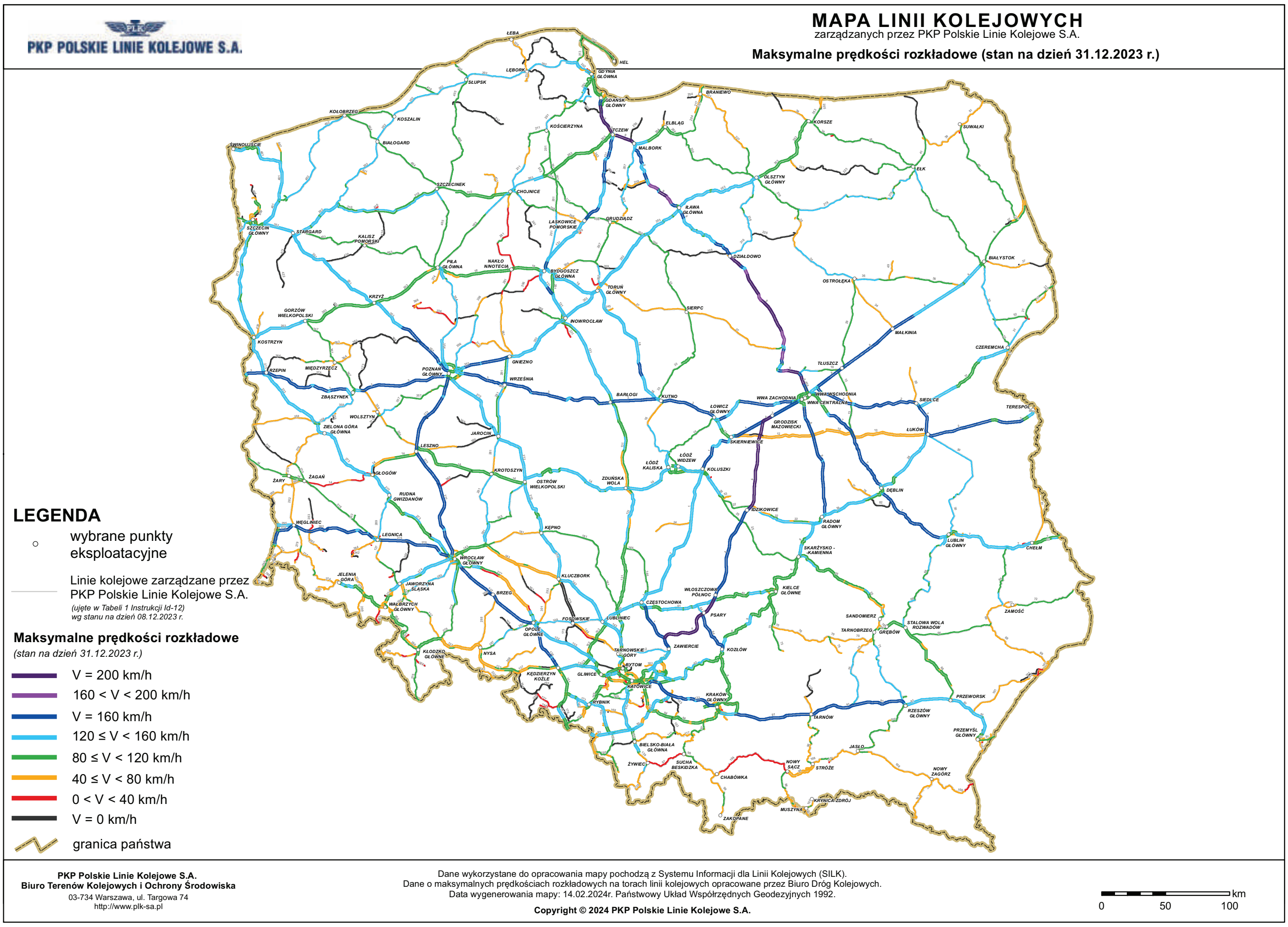
Unfortunately, examples of this are not hard to find—one only needs to look at the large-scale flow of weapons, armaments, and ammunition facilitated by Poland in support of the Ukrainian armed forces [3].

The political, economic, and social awareness processes that have unfolded in Europe over the past two decades have laid the groundwork for an energy revolution driven by the necessity of environmental protection. Europe, particularly the European Union, has committed to moving away from coal and fossil fuels in favour of energy derived from renewable sources. A 'roadmap' has been devised to guide Europeans towards the ultimate goal of 'zero emissions.' However, this transition is proving to be extremely costly and fraught with numerous 'economic traps' that experts had warned about—warnings that, for the past twenty years, were largely ignored by political circles. One such challenge is the relatively low price of crude oil and petrol, which has led to an increasing reliance on road transport, facilitated by an extensive network of motorways and express roads. Unfortunately, few decision-makers seem to grasp the fact that the capacity of these road networks is already at its limit, constraining the efficiency of road transport operations. This raises a pressing dilemma: how can emissions be reduced without significant financial investment or extensive efforts when the economies of numerous EU countries remain dependent on crude oil and natural gas, as well as, to a considerable extent, on coal—both hard and lignite? In this regard, Poland serves as a prime example [5], [6].



1. Railway network in Europe. Source: https://mapy.net.pl/mapa-scienna-europy-koleje-karta/6854

As part of the research undertaken, the authors of this publication employed three scientific methods from a broader set of available approaches. The most significant among them is the method of critical rationalism, rooted in the philosophical school of Karl Popper. This method enables a critical examination of existing studies to generate



2. Railway line map of Poland
Source: Biuro Prasowe PKP, https://www.plk-sa.pl/o-spolce/biuro-prasowe/mapy (21.11.24)

Tab. 1. Freight transport in million tonnes from 2017 to 2023

2017	239.9
2018	250,3
2019	236,4
2020	222,3
2021	243,6
2022	248,5
2023	231,7

Source: Own elaboration based on data from Polish State Railways

appropriate conclusions and, in doing so, avoid errors. It also allows for a profound modification of existing assumptions while maintaining fundamental general principles on which theories, premises, and previously developed models of action are based. When combined with other scientific research methods, this approach facilitates the development of a model for achieving strategic state objectives in the field of railway freight transport, based on existing information and statistical data. Complementary to critical rationalism are the case study method and the scenario method.

In the field of literature relevant to the scientific research, the authors focused on materials from analytical centres and information available to Polish State Railways and Polish Railway Lines—excluding, as a matter of course, any sensitive data. Complementing the conducted research is the literature characteristic of this type of study, including monographs, reports, articles in printed publications, and, naturally, netographic sources, in line with technological progress and the spirit of the times.

Polish State Railways and Polish Railway Lines in the face of challenges posed by the energy crisis

Polish State Railways and Polish Railway Lines employ over 100,000 workers, combining passenger and freight transport while managing railway infrastructure. For many years, cargo transport has been a cornerstone of the railway's strength, underscoring its significance not only in domestic economic circulation but also on a broader European—and arguably even global—scale. The total length of railway lines in Poland is approximately 19,500 kilometres, placing the country third in the European ranking, behind the Federal Republic of Germany and France. This highlights Poland's strategic transport potential [7]. The geopolitical position of our country, which should be a key element of Poland's strategic culture and serve as the foundation for considerations regarding modifications to the national raison d'état, predisposes us to a broader utilisation of transport routes than has been the case so far. Despite the ongoing war beyond our eastern borders, Polish State Railways has managed to maintain a number of railway lines that serve as a pivotal connection between the broadly defined West and East.

As a result, opportunities have arisen to utilise our transport routes for importing goods from the People's Republic of China, South Korea, and, to a certain extent, even Japan, despite its island location. The potential of Polish State Railways and Polish Railway Lines, measured by the strength and significance of existing transport routes, should therefore be considered high.

The data summarised in the table, supplemented by railway connection maps, clearly indicate the significance of rail transport, as highlighted by the authors in the introductory part of the article, identifying rail as one of the two most important modes of transport. The noticeable decline in freight transport tonnage is influenced, among other factors, by the difficult wartime situation unfolding beyond Poland's eastern border, as well as by sanctions imposed on Russia, a key rail carrier in the European transport corridor. However, in the latter case, the sanctions do not cover a range of goods originating from Russia, nor do they significantly affect goods in transit through Poland from Asian countries [8]. On a more positive note, a record-breaking result of 61.7 billion tonne-kilometres was achieved—the highest in a decade—although profitability remains an open question. On the other hand, the extension of transport routes for both passenger and freight services is driven by the ongoing modernisation of railway networks. Unfortunately, there is still no structured programme to increase expenditure on necessary transport infrastructure, including the acquisition of new freight rolling stock, not only with varied technical specifications but also tailored to specific transport needs. In other words, a clear determination of the types of goods expected to be transported in the coming years is required, particularly in relation to potential declines in specific freight categories. It is also increasingly apparent that, as Poland continues aligning its legislation with European Union regulations, foreign economic entities are entering the Polish freight transport market. These companies often offer at least comparable and, in many cases, a broader range of services at prices similar to those proposed by Polish rail operators. Given these circumstances and the fact that by 2035, Poland will be required (unless national and supranational regulations change due to socio-economic factors and Europe's declining competitiveness) to comply with European low-emission standards, rail transport will have a crucial role in shifting a significant share of goods that are currently transported by road-based logistics companies using Poland's extensive motorway network [9], [11].

On the one hand, this presents a great opportunity; on the other, it necessitates immediate capital-intensive preparatory actions.

Freight transport costs: a comparative analysis and critical studies

Considering the above discussion, it is essential to move towards a concrete economic analysis of the profitability of rail transport in comparison to road transport. However, it must be noted that the authors of this publication are unable to account for all factors influencing the overall assessment. Nevertheless, they believe that their analysis is sufficient to articulate certain conclusions that could serve as a foundation for an inevitable discussion on the future of transport, given the significant transformations occurring in the global transport market. An analysis based on source documents from PKP Cargo and Cargo International indicates that, at present, it is not possible to definitively determine whether rail transport has a cost advantage over road transport. Naturally, this conclusion is drawn based on the current knowledge available within the examined research field. This article's argument is shaped by both internal factors, which are largely within domestic control, and external factors, which fall within the domain of international relations. Another issue is the use of rail transport for container shipping. In this case, the cost-effectiveness of container transport primarily depends on whether a train operates on a round-trip basis (charging fees for both departure from the home station and the return journey) and whether the entire train is fully loaded. Given the above considerations, it appears that achieving success, measured in terms of low cost-intensiveness while also considering transport security, depends not only on calculating a specific unit cost but also on the operator's ability to manage transport efficiently. The key lies in having the capability to make informed decisions about the appropriate choice of transport mode. Based on the above, the following conclusion can be presented to the reader: offering transport and terminal services from a single provider, as practised by Metrans or PCC Intermodal, allows the operator to retain the margin on both transport and transhipment services.

And this, in fact, may pose a significant challenge, as in road transport, specialised individuals (often even working alone (!)) handle operations with access to a computer system that pairs transport orders. This system allows a given contractor to commission transport from city X to city Y while simultaneously securing a return load from the vicinity of city Y to another designated location (for example, another city in Po-

Tab. 2. *Bulk goods*

		Price [€/tona]		Route [km]	Price [€/tonne]	Total [€]	Unit cost [€]
		from	to				
Coking coal	Train transport (2 to 2.2 thousand tonnes)	18,2	20	600	19,1	38 200,00	19,1
	Truck transport (29-30 tonnes)	25	26	600	25,5	51 000,00	25,5

Tab. 3. *Containers: 40-foot*

	Price [€/tona]		Route 600 km [€/unit avg.]	Qu-antity [units]	Cost [€]	Average unit cost [€]	Land terminal + last mile [€]	Total [€]
	from	to						
PTrain 42 units one way for roundtrip organisation	260	350	305	42	12 810	305	200	505
Roundtrip 42 units	510	700	605	42	25 410	605	400	1 010
Truck	1,25		750	42	31 500	750	0	750

land). In this way, goods are transported in both directions, reducing transport costs while increasing the profit margins of both the carrier and the logistics planners responsible for freight forwarding. Thus, the key to resolving rail transport challenges also lies in efficient management of IT systems and their integration into a widely accessible network. Unfortunately, while a road transport provider can accept an order for just a few tonnes of material, rail transport largely requires filling an entire train, which makes it unfeasible for transporting small loads unless similar or complementary shipments are found to consolidate with the initial consignment. This situation could be improved by a logistics model based on container transport. However, the main issue here is the lack of appropriate transhipment infrastructure and certified storage facilities that meet security standards. Investments in these areas are therefore essential and—crucially—require support from the Polish state as well as European Union institutions. The current state of Polish public finances, particularly the dominance of short-term priorities (such as national defence) in government spending, severely limits the possibility of significant capital investment in modernising and expanding railway infrastructure. One potential solution is financing the investment portfolio through funds channelled via European mechanisms.

In the analysed case, the rate per container depends on the gross weight of the entire train (which results from access charges to the PLK network infrastructure) in which the container is transported, as well as on the number of wagons in the train (the more wagons, the lower the unit price). If we add the margin of the carrier/forwarder, we can assume PKPCI calculations, although terminal costs at Paskov (200 EUR per container) should be added. However, for the analysis to be meaningful, the handling rate in rail transport (highlighted in yellow) should be compared to the road transport rate. Road transport operates on directional rates that cover the cost of an empty return journey.

In rail transport, however, rates are calculated for the entire cycle because including the empty return of the wagon set to the departure station would make rail transport non-competitive from the outset. Additionally, terminal costs at the land terminal and delivery to the consignee should also be included; port costs remain the same for a container, regardless of the type of transport. A standard lorry from the port delivers the goods to the final customer under the so-called door-to-door service, which is the main difference between road and intermodal transport. Returning to container transport, the container from the train must be reloaded onto a lorry at the terminal (assumed cost of 50 EUR) and delivered to the final customer (assumed cost of 150 EUR for delivery up to 50 km). Rail freight rates can be reduced by extending the train where possible. On the Paskov route, it is certainly possible to use 620-metre-long trains, allowing for the calculation of 44 containers instead of 42.

The second optimisation factor is transporting containers loaded in both directions, where possible. In this case, the highest rate per container is paid, but the client is charged twice for transporting the container in both directions. Another crucial element of this analysis is the simultaneous offering of transport and terminal services.

It should also be noted that it is not possible to establish a universal cost share for rail transport. In the case of an old, fully depreciated diesel locomotive, the cost burden will be significantly lower than for a multi-system electric locomotive. Furthermore, if own depreciated wagons are used, the costs will be considerably lower than when transporting rented tank containers, pocket wagons, or standard wagons. If private wagons (belonging to the client) are used, they are free of charge, and the proportion of other costs increases relatively.

The duration of loading and unloading is also significant—whether the locomotive waits or leaves impacts the final price. Another key consideration is whether the cost of the locomotive's arrival at the loading point must be included in the price; in many cases, the client does not wish to pay for it, but the company still incurs the cost. Additionally, infrastructure charges for intermodal and conventional transport differ.

Overall, there has been a decline in the domestic freight market involving low-cost diesel locomotives (such as coal transport and servicing steel mills). New projects are increasingly geared towards cross-border transport, where it is more convenient to complete the entire route with a single locomotive. However, this requires the implementation of multi-system locomotives, whose costs remain high until they are fully utilised.

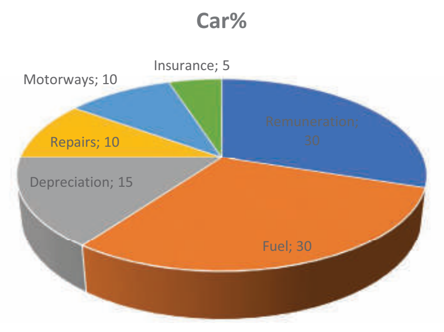
In the same way, modern wagons may have higher prices but often offer greater capacity—therefore, an optimal solution should always be sought for the client.

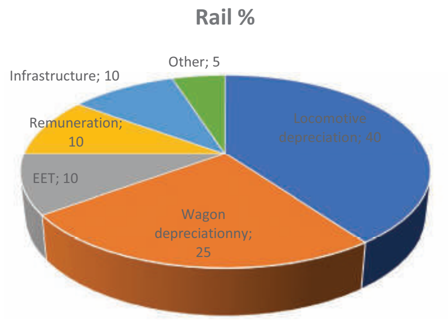
The cost structure of the freight transport process is presented in Fig. **3**.

The above calculations clearly highlight both similarities and differences between the two types of transport. The most prominent factor is locomotive depreciation, which accounts for 40% of expenditure. In the case of road transport, this figure is only 15%.

Rail transport, on the other hand, stands out positively in terms of wages and—most importantly—fuel. Fuel costs make up 30% of the expenses in road transport.

Considering the need to transition from hydrocarbon-based fuels to renewable energy sources (RES), road transport would have to rely on electric propulsion. Given the current state of the electric vehicle market, the efficiency of such projects remains highly debatable. Thus, investing in rail transport in an





3*. Cost structure of the freight transport process. Source: Own elaboration based on PKP data P* era of climate policy changes appears to be a well-thought-out decision. However, this is only valid under rational assumptions regarding the timeframe and costs of the energy transition—factors that have not yet been accounted for.

Referring to the thesis adopted by the authors of this study, and assuming that the plans set out by EU policymakers to replace internal combustion engines with electric engines by 2035 will indeed materialise, it is necessary to consider not only the efficiency of electric engines (which, given the current state of technological development, remains questionable) but also the costs arising from the need to generate additional energy capacity. If we assume that road transport accounts for 33% of the total transport market in Poland, an increase in energy capacity would be required to replace liquid fuels as part of the transition to new propulsion systems. Although this process would be spread over time due to the gradual phasing out of internal combustion engine vehicles, the burden on the Polish energy system would involve the need to generate an additional 312.51 TWh. Poland currently has a total of 875,861 km of power transmission lines: 15,964 km of 750 kV, 400 kV, and 220 kV lines, 34,376 km of 110 kV lines, 321,089 km of medium-voltage (SN) lines, and 504,492 km of low-voltage lines. Following this line of reasoning, national Transmission System Operators would have to significantly expand the length and capacity of the network (some experts even suggest a doubling of distribution and transmission capabilities). It is important to note that the increasing failure rate of the grid due to weather conditions, combined with the limited capacity of high-voltage transmission and distribution lines (110 kV) at higher temperatures, already poses a significant risk to system stability. This is especially critical given the growing demand for energy and the uncontrolled, rapid increase in the connection of unstable power sources.

These calculations provide a strong basis for discussion regarding the rationality of the adopted solutions in this area. Total investment expenditures (as of 2022/2023) would amount to approximately PLN 650 billion. The estimated cost of constructing 1 km of a 110 kV line is around PLN 1.2 million, for a medium-voltage (SN) cable line, approximately PLN 400,000, and for railway traction, between PLN 800,000 and PLN 1 million.

It is worth noting that the barrier to infrastructure development is not only the availability of financial resources but also the organisational and operational capacity of investors and contractors/designers available on the market.

Unfortunately, the above costs do not represent the total costs of the energy sector transition, that is, the shift from hydrocarbon-based fuels to clean energy. The necessary additional energy capacity to sustain such a system would require the construction of a number of nuclear power plants (with renewable energy sources playing only a supplementary role, not only due to their insufficient efficiency but also their instability in supply). An additional 72,393 MW would need to be introduced into the system, with the financial scale of this challenge amounting to PLN 1.86 trillion. Two years ago, the cost of servicing the transition and building new capacity in Poland was estimated at PLN 1.4 trillion, and this amount continues to grow. At that time, the cost of strengthening distribution networks in line with the EU Green Deal was estimated by EDSO (the European Distribution System Operators' organisation) at EUR 600 billion.

To summarise, the phasing out of internal combustion engines as the primary transport power source must be extended beyond the timeline set at the EU member state level. A gradual transition to a system that utilises not only renewable energy sources but, above all, nuclear energy is essential. Additionally, the balance between centralised management of energy generation and distribution and the development of local networks and generation sources must be maintained. At present, the Polish state lacks the financial capacity to undertake expenditures of this magnitude, particularly given its substantial budget deficit, which—contrary to political promises—is likely to necessitate investment cuts rather than further stimulus. Worse still, over the next five years, even with budgetary expenditure reforms, the authorities will not be able to eliminate the deficit entirely, but only significantly reduce it at best.

Undoubtedly, rail transport is key to the energy transition, but only on the condition of substantial investments in railway infrastructure, alongside essential investments in energy production and distribution infrastructure. The transition from hydrocarbon-based energy to emission-free energy, initiated by the EU authorities and set to be implemented by the Polish government, is fundamentally a sound strategy, but it must be rationalised—meaning it should be extended over time and take into account various needs, including the costs of railway modernisation.

The involvement of EU member states in developing legal regulations to support rail transport while limiting the attractiveness and profitability of road transport is also of great significance.

One such approach is government programmes like 'Trucks on Rails,' which, despite being heavily criticised and obstructed by the road transport lobby, aim to shift freight from roads to railways. It must be emphasised that the apparent cost advantages of road transport are offset by measurable expenses, including the degradation of road infrastructure, greenhouse gas emissions, and the social cost of congested roads and their associated negative impacts. Consequently, legislation plays a crucial role in increasing the importance of rail transport and safeguarding the legitimate interests of the state and its citizens.

EU institutions and the development of rail transport in light of the new climate policy

In recent years, the efforts to provide greater support for rail transport have accelerated, following an earlier, intense debate within the European Union's decision-making circles, which are responsible for laying the groundwork for the future common transport policy. At present, it is difficult to definitively assess whether there will be sufficient resources, funding, and perseverance to successfully implement the projects that are essential for European single markets.

In an attempt to evaluate both the potential and limitations of the EU's sectoral policy in the broadly defined transport sector, the authors of this study have chosen to focus on two key documents that, in their view, were created specifically to guide EU policymakers. Accordingly, it is worth noting and subjecting to critical analysis two recently published reports commissioned by the European Commission, both of which suggest the necessity of redefining the existing rail transport policy while simultaneously developing a new, more synchronised framework, but this time at the EU institutional level.

The first of the reports, focusing on the mechanisms and rules governing the EU Single Market, is a document authored by Dr Enrico Letta, President of the Jacques Delors Institute, legal scholar, political scientist, and Member of the European Parliament. The report, *Much More than a Market. Speed, Security, Solidarity. Empowering the Single Market to Deliver a Sustainable Future and Prosperity for All EU Citizens* [12], outlines key recommendations aimed at strengthening the Single Market to ensure sustainability and economic well-being for EU citizens.

The second report, which lays the groundwork for changes in the perception of sectoral policies, including the European Union's transport policy—a key area of interest for the authors of this publication—is a document authored by former Italian Prime Minister and Professor of Economics Mario Draghi, The Future of European Competitiveness. This document was commissioned by the President of the European Commission, Ursula von der Leyen, who recognised the necessity of introducing new economic initiatives aimed at revitalising the stagnating

Tab. 4. *Key conclusions from Enrico Letta's report*

Conclusion	Adaptation of freight and passenger rail transport to meet the requirements of the EU climate policy implementation
Conclusion	Digitalisation of rail transport
Conclusion	Improvement of railway and railway-related infrastructure
Conclusion	Creation of legal, institutional, and technological conditions for the development of high-speed rail

Source: Own elaboration based on E. Letta, Much More than a Market. Speed, Security, Solidarity. Empowering the Single Market to Deliver a Sustainable Future and Prosperity for All EU Citizens, Brussels 2024

Tab. 5. *Conclusions from Mario Draghi's report*

Conclusion	Increased pro-investment expenditure aimed at accelerating the development pace of the European Union
Conclusion	Increased funding for science
Conclusion	Focus on innovation and new technologies as a response to the expansionist policies of the PRC and the USA in this area (eliminating existing delays)
Conclusion	Integration of European economic development with the EU's new climate policy, based on alternative energy sources in relation to existing ones
Conclusion	Investments in the broadly defined security sector of the European Union

Source: Own elaboration based on M. Draghi, The Future of European Competitiveness, https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en (19.11.24)

European economy [14].

The document prepared by Mario Draghi, with expert support, provides some hope for the realisation of the main theses contained in the report, including those related to the railway sector. The latter, based on new technologies that utilise renewable energy sources as propulsion while emitting no atmospheric pollution, appears to be a natural candidate for investment. Rail transport is an investment in the future—this is well understood by all those involved in global transport. However, the challenge lies in translating declarations into action. As the era of internal combustion engines draws to a close—whether at a faster or slower pace, depending on expert assessments—an alternative to road transport must be found. Developing innovative solutions based on mature technologies will be essential; without this, it will be difficult to establish the foundations not only for a modern railway system but also for transport as a whole [16].

Moreover, in the later sections of the report, its author firmly emphasises that in order to fill missing links and modernise transport infrastructure, it is necessary to generate financial resources that are crucial from the perspective of European strategy in the analysed area of sectoral policies. For example, the modernisation and expansion of the TEN-T network, which is preliminarily planned for completion by 2040, will cost European taxpayers nearly €845 billion, of which €210 billion is earmarked for strategic cross-border connections. It is expected that EU public funding will cover only a small portion of these investments (with projected expenditure of up to €87 billion by 2027). However, the total amount of planned funds may prove to be vastly insufficient in relation to the ever-growing needs. The question of private financing also remains open. This issue concerns not only the feasibility or scale of private funding but also, equally importantly, the legal instruments that will enable the smooth implementation of projects in this area. So far, private financing has been difficult to secure despite, it is worth noting, a mature portfolio of TEN-T projects. This is due to their high level of risk, substantial initial costs, and, more recently—amid the economic instability in Europe—the short-term loss of profitability. To date, rail transport, despite numerous promises, has not received particularly generous funding from EU resources. Other modes of transport have enjoyed significantly greater support, especially when considering the scale of investments. As of 2025, the planned road network remains by far the most developed compared to other forms of transport—as if the issue of phasing out hydrocarbons did not exist or there were still ample time to implement this undoubtedly transformative process in the history of not only the European but also the global economy. Thus, the key challenge now facing EU decision-makers is to ensure that non-road investments are realised over the next decade. Beyond what has been planned within the TEN-T framework, the development of a high-speed rail network connecting all EU capitals and major cities would enhance the attractiveness of rail transport and further amplify investment needs [17].

In his report, Mario Draghi also highlights the increasing volume of road transport, despite the implementation of the new climate policy. EU member states continue to prioritise investments in road infrastructure. This approach yields quick returns and is easier to implement compared to railway investments, which require significantly more advanced technological input and a broader scope of work.

Another issue raised in the report is the so-called "bottleneck" in freight transport via rail, which significantly limits its capacity. However, these limitations are a direct consequence of investment shortfalls. Without the EU's commitment to building new and modernising critical connections, rail transport will remain at a disadvantage compared to road transport. The latter, however, is unsustainable in its current form due to the implementation of the climate neutrality policy. Without the necessary investments, the operational viability of railway rolling stock is becoming increasingly deficit-ridden, particularly given the rapid rise in demand for freight transport, which member states persistently choose to handle via road transport. This approach contradicts efforts to resolve existing "climate dilemmas" and is further complicated by the decreasing capacity of key transport routes (e.g. the Suez Canal, the Panama Canal). Additionally, limited capabilities in ensuring the security of maritime shipping routes further exacerbate the problem. This is due to the increasing prevalence of piracy (e.g. off the coast of Somalia) as well as terrorist attacks targeting shipping lanes, particularly those involved in transporting energy resources, as evidenced by Houthi attacks in the Gulf of Aden [16].

The challenges requiring a reinterpretation of the European Union's transport market also stem from the lack of integration within EU transport systems, which accumulates various negative economic phenomena and directly affects the low competitiveness of EU member states in the global transport sector. It is also difficult not to observe that, despite significant progress in building an integrated EU transport market, numerous barriers still hinder the final implementation of this much-needed common policy. Among these, attention should be drawn to the issues surrounding the interpretation of applicable legal norms arising from the EU legal order or other organisations such as the WTO. Unfortunately, the Member States of the Community have a tendency to interpret EU regulations inconsistently. This is particularly difficult to prove, as the mere translation of legal acts generates numerous problems and, at times, even fosters interpretations that are unfavourable from a broader perspective. Another issue is the sluggishness of decision-making processes in the implementation of new or the updating of existing legal norms. This hinders, and in some areas outright prevents, the emergence of new EU entities in transport, travel, and the broadly defined logistics sector. The latter remains a proverbial 'Achilles' heel,' manifesting itself in the lack of a digitalisation programme that is adequate to the challenges posed by the global market. The analysed report indicates that currently, only 1% of cross-border operations within the EU can be conducted entirely digitally; in other words, just one in a hundred transport operations does not require physical documentation at various stages of the process. It is estimated that newly adopted digitisation rules, particularly those concerning the exchange of information in freight transport (road, rail, inland waterway, and air transport), could yield savings of nearly USD 30 billion over the next two decades. Artificial intelligence is set to enable increasingly automated functions that enhance safety and quality, optimise navigation and routing, support predictive maintenance, and reduce fuel or energy consumption. A major challenge remains the implementation of AI-based solutions. Artificial intelligence appears indispensable in shaping the objectives of an integrated transport strategy within the EU, particularly in the railway sector. In this area of integrated transport, AI could facilitate planning changes, improve energy efficiency, and enable the rapid deployment of service planning or real-time disruption management. Compared to other global powers, particularly the USA and China, the EU lags significantly behind in this regard [16].

Another key objective for the EU in the coming years, according to the assumptions outlined in the analysed report, is the complete decarbonisation of the economy, which will significantly impact transport, particularly rail transport. Data provided by the European Commission clearly indicate that moving away from the "coal era"—a distant echo of the industrial revolution of the 18th and 19th centuries—will reduce CO2 emissions by 80%. However, achieving this will require substantial financial resources to implement the necessary changes, launch further projects in both the economic and social spheres, and introduce new innovative solutions. Investment needs for the decarbonisation of EU transport between 2025 and 2030 are estimated at €150 billion, with an additional €869 billion required between 2031 and 2050, which serves as the timeframe for EU policy objectives. It is worth noting that these estimates encompass the decarbonisation of all modes of transport (excluding the costs of maintaining railway and road infrastructure), meaning they do not provide a complete picture of the financial scope of this undertaking. A separate issue in this context concerns Poland, which, apart from the Czech Republic's minimal remaining contribution, is the last coal producer in the EU. This raises the question of Poland's decarbonisation prospects. So far, Polish policymakers have maintained a remarkably passive stance, seemingly waiting for someone else to resolve this issue, which is crucial for the future of the national economy. This indirectly affects the railway sector as well, given that electrified rail transport in Poland is primarily powered by electricity generated from hard coal and lignite [18].

The EU transport sector, much like the broader community economy, is struggling with a shortage of adequately skilled specialists—those capable of carrying out tasks arising from the implementation of new sectoral policies. These challenges are particularly pronounced in the transport industry. Unfortunately, the sector offers relatively unattractive working conditions, influenced by factors such as high occupational stress and, ultimately, remuneration levels. A significant challenge is the increasing proportion of older workers, which is notably higher in the transport industry than in other sectors of the EU economy. According to statistical data provided by the European Commission, as many as 41.9% of railway transport employees are over the age of 50, and the average age of truck drivers in the EU is the highest in the world. This trend also applies to the average age of train drivers operating freight and passenger services. Additionally, the participation rate of women in the transport sector remains low. According to Eurostat statistics, women account for only 22% of transport industry employees [16].

It should be noted that the railway markets of the EU Member States remain highly decentralised. While decentralisation is generally regarded as a tool for positively shaping reality, its doctrinal application has not proved particularly effective in the case of rail transport. There are several reasons for this state of affairs. It is undeniable that, despite numerous assurances and declarations from EU policymakers, the planning and coordination of both passenger and freight transport are still not effectively managed on a cross-border scale. Instead, these responsibilities remain—one could argue almost exclusively—the domain of individual Member States, which often act contrary to the ideal of European unity, prioritising national policies that fail to account for global challenges. According to Eurostat data, there are still nearly 800 national regulations governing railway transport across the EU. Operational requirements also vary significantly across Member States. Moreover, market barriers persist for new entities seeking to enter the railway sector, despite the declared commitment to fostering competition. One example of such restrictive policies is the high track access charges, not to mention the numerous difficulties in accessing rolling stock and ticketing systems—elements that, according to policymakers, were supposed to be a shared space for cooperation among various railway operators. This undoubtedly has a negative impact on the potential ability of service providers to scale up their operations, and even more so on their capacity to conduct business on a cross-border level. Operators active in more than one national market remain exceptions across the EU. These facts have clear consequences. The number of long-distance cross-border rail services in Europe has, over the past twenty years, remained practically stagnant, showing no real growth. Among other issues, there is a lack of high-speed connections—despite the fact that time, much like information, plays a key role in the global economy—the complexity of the booking system for multi-stage journeys, and the absence of in-depth studies on passenger rights. In this last case, changes are necessary, not least because of the expanding catalogue of rights, freedoms, and civil liberties, which are an essential part of a modern civic society [16].

Significant changes are required in rail freight transport, which has experienced a relative decline in priority, even compared to passenger rail services. This leads to delays, directly affecting the perceived reliability of this mode of transport. And yet, the foundations exist for the further sustainable development of intermodal freight transport. There are EU legal standards aimed at promoting intermodal transport, with the key piece of legislation being the Combined Transport Directive adopted in 1992. Unfortunately, the rapidly changing reality—including developments in both passenger and freight transport—necessitates an update of legal provisions that were initially introduced to address the challenges of the early 1990s, while humanity has long since entered the third decade of the 21st century. Despite these challenges, intermodal transport has seen substantial growth, as evidenced by Eurostat data from 1996 to 2016, showing an increase of approximately 400%. However, nearly 50% of intermodal operations currently carried out within the EU remain outside the scope of support envisaged under the now highly outdated directive [16].

Among other key issues, the need to integrate digital solutions with existing older generations of railway traffic management systems also deserves attention. The lack of full harmonisation of member states' railway networks at the central EU level hampers the creation of an interoperable system for railway management, control, and signalling, despite the efforts of several EU institutions working towards this goal. The European Rail Traffic Management System (ERTMS), which has been successfully implemented in several non-EU countries and was introduced by the EU as a mandatory system for member states, is still rarely applied in practice. According to data from the European Commission, by 2050 (the target year for the EU's strategy), the estimated investment required for full implementation should reach nearly USD 250 billion. An open question remains as to whether the financial resources planned by the EU will be sufficient to meet the objectives set for implementation, particularly given the necessity of undertaking multiple strategically significant investments. These include projects aimed at increasing railway capacity: Future Railway Mobile Communication System (FRMCS), Digital Capacity Management (DCM), and, no less importantly, Digital Automatic Couplers (DAC). Given the anticipated evolution of these solutions, the EU must be prepared for the rapid deployment of an automated capacity allocation system. At present, capacity allocation occurs only at the national level and is typically carried out without the use of modern digital tools. One might venture the opinion that the world is outpacing European railways—at least in this specific area highlighted by the authors of this publication [16].

Conclusion

The above scientific article serves as an introduction to a necessary discussion in light of changes driven by numerous external and internal factors. The first category includes the inevitable shifts in the global balance of power, not only at the political level but also in the areas of security and the economy. A manifestation of this is the war taking place beyond our eastern border, where railways, as a primary means of transport, play a crucial role in NATO's transport strategy. The second category of challenges—those of an internal nature—affects not only Polish State Railways but also the state authorities. Adapting to the regulations set to take effect under the Green Deal requires massive investment in modernisation, expansion, and technological development of the existing production and transmission capacities within our energy sector. The costs of this process far exceed the financial capabilities of our state, as demonstrated in the economic analysis presented in the earlier sections of this publication.

It is therefore essential to rationalise this process while simultaneously shifting transport from road to rail. This is particularly significant given that rail transport accounts for only 1.5% of CO2 emissions into the atmosphere—an almost negligible figure in environmental terms when compared to the emissions generated by road transport. However, the current financial capacity of the railway sector to fund necessary investments remains severely limited.

Examples of serious financial problems faced by the Romanian, Czech, German, and now unfortunately also Polish railways in the transport sector seem to contradict the assumptions of the Green Deal.

We are dealing with an incomprehensible paradox: while committing to phasing out internal combustion engines by 2035, we simultaneously take measures to strengthen road transport (expanding road networks, offering toll-free motorways, and maintaining low fuel prices).

In such a defined reality, rail transport becomes unprofitable, which must inevitably lead to an absurd situation where, in constructing the new Green Deal, we ultimately base it entirely on hydrocarbons—achieving an outcome entirely opposite to the intended objectives.

An immediate transformation is therefore necessary in the form of expanding railway infrastructure, making use of existing opportunities, such as land ownership, from which the railway already benefits. This process must be spread over years, include concrete solutions, and have a defined budget with substantial financial resources. Without these resources—without a rational and, unfortunately, costly strategy to prioritise rail as an environmentally friendly, safe, and efficient mode of transport—it will be difficult to speak of a full energy transition, let alone a broader economic transformation of our country. The European Union should also play a crucial role in this process, as it has a vested interest in Poland's railway infrastructure, which serves as a key link between the West and the East, as well as a strategic element of security on NATO's eastern flank. ◀

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Poland's Path to High-Speed Rail – Analysis of Challenges and Development Prospects

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Abstract: This article analyzes the prospects and scenarios for the development of high-speed rail in Poland against the backdrop of experiences from other European countries. Despite early investments, such as the Central Rail Line from the 1970s, Poland remains behind in the process of European high-speed infrastructure. A significant change in this regard was the introduction of speeds of 160 km/h and subsequently the introduction of Pendolino trains. This improved the quality of transport; however, their full potential (250 km/h) is still not fully utilized. Planned investments, including the modernization of the Central Rail Line and the construction of the "Y" high-speed line (Warsaw–Łódź–Wrocław–Poznań), aim to significantly increase train speeds and enhance the competitiveness of rail transport. An analysis of the experiences of France, Germany, Italy, and Spain indicates positive economic and environmental effects of implementing high-speed rail systems, while also highlighting different planning and operational models of individual HSR (High-Speed Rail) systems. This allows for the assessment of individual models in terms of the applicability of their elements in the implementation and development program of the high-speed rail system in Poland.

Keywords: *High-speed rail; Rail infrastructure; Investments*

Introduction

Rail plays a key role in the development of transport infrastructure in Europe, providing an alternative to both road and air transport (Givoni, 2006). In particular, high-speed rail has become a pillar of mobility in Western European countries, leading to significant changes in travel patterns and impacting the economy, environment, and spatial organization of regions and urban agglomerations (Campos & De Rus, 2009).

Poland, despite early investments in rail infrastructure, such as the Central Rail Line (CMK) built in the 1970s, has not yet developed its own high-speed rail system. Compared to Western European countries that have dynamically implemented high-speed solutions since the 1980s, Poland lags behind in both technology and transport organization (Preston, 2012). The aim of this article is to analyze the consequences of delays in the implementation of high-speed rail in Poland, identify key challenges, and analyze European experiences in the development of HSR networks and the possibilities for their application in Poland.

History and Current State of High-Speed Rail in Poland

Poland was one of the first countries in Central and Eastern Europe to take steps towards building rail infrastructure enabling high-speed transport. An example of a project planned and implemented according to this concept is the Central Rail Line (CMK), construction of which began in 1971. The line was designed for speeds of up to 250 km/h; however, over the following decades, it was not fully adapted to high-speed rail standards (Konieczyński, 2015). A significant milestone in increasing speeds on the Polish rail network was the introduction of a speed of 160 km/h on the CMK in 1988. Unfortunately, the deep political and economic changes that occurred a year later halted further work in this direction. In the following years, such work was carried out slowly and unsystematically. After the political transformation, the railways in Poland found themselves in a very difficult financial situation, resulting in a sharp reduction in investments in infrastructure and rolling stock. Thus, the speed of 160 km/h remained the maximum value for the next 36 years. It was only in December 2014, after further modernization works, that a speed of 200 km/h was introduced in regular traffic. First on line no. 4 (CMK), and six years later on line no. 9, which extends towards Gdańsk. This was made possible by the engagement of the first HSR trains in Poland, the ED250 series "Pendolino." It is worth noting that the vehicles delivered in 2012 operated at that time at a speed of 160 km/h and still do not utilize their maximum speed of 250 km/h (Konieczyński, 2015).

Since the design and construction of the CMK, several dozen more or less advanced concepts, studies, and projects for the development of the Polish high-speed rail network have been prepared. Alongside the further increase in speed on the CMK, the most mature and closest to realization is the construction of the so-called "Y" line, which is to connect Warsaw, Łódź, Wrocław, and Poznań. In this case, it has been possible to move from conceptual work to the design stage and obtaining the required approvals and permits, and in selected elements, even to the execution of construction works. The construction of the first section of the new high-speed line between Warsaw and Łódź is planned for the years 2027–2032. A design speed of 350 km/h has been adopted in this case (PKP PLK, 2023). At the same time, it has been declared that in the following years, the expansion of infrastructure dedicated to HSR transport towards Wrocław and Poznań will continue, and in subsequent stages also to Gdańsk and on cross-border sections in the south of the country.

European experience in high-speed rail construction

Historically, the area of the first HSR projects was Japan and Europe. In Asia, the first high-speed lines began to be constructed in the 1960s, while in Europe, this occurred in the 1980s (Towpik, 2010). Currently, the European HSR network encompasses over 11,000 km of tracks (UIC 2020).

Examples from countries such as France, Germany, Italy, and Spain demonstrate that the implementation of high-speed rail leads to a systematic strengthening of the competitive position of railways, improved mobility, economic development, and reduced CO_2 emissions. It is also worth noting that each of these countries adopted a slightly different strategy for building and managing HSR infrastructure, tailored to the specifics of the local transport network and geographical and socio-economic conditions. An analysis of these experiences can provide Poland with valuable insights regarding the planning and implementation of similar projects

France

France was the first country in Europe to implement a dedicated HSR network, becoming a global leader in this area. The TGV (Train à Grande Vitesse), or French high-speed train, began operations in 1981 with the opening of the new Paris–Lyon line. It was a response to the growing competition from air transport, which was taking passengers away from rail on short- and medium-distance domestic and European routes. The systematically expanded HSR network has reached a length of over 2,800 km, offering the possibility of speeds up to 320 km/h.

The French high-speed rail model is characterized by the construction of entirely new, independent high-speed lines (LGV) that are not used by freight trains or conventional passenger trains. This allows for very high average travel speeds and high frequency resulting from the uniform nature of the traffic.
The French high-speed rail system has several key features:

- the construction of new lines dedicated solely to high-speed trains and the separation of HSR traffic from other trains,
- integration of HSR with other modes of transport at multimodal transfer hubs,
- significant investment from the state budget, supported by industrial policy in the production of rolling stock and infrastructure elements, as well as the use of public-private partnerships (PPP),
- a focus on competitiveness against air transport and capturing traffic not only on domestic routes but also internationally with neighboring countries,
- economic benefits stimulating regional development.

The aforementioned separation of high-speed rail from conventional traffic is one of the key elements of HSR success in France. The construction of a separate network of lines dedicated solely to high-speed rail brings benefits in the form of:

- reliability and punctuality, resulting from the absence of conflicts with regional and freight traffic,
- the ability to achieve high commercial speeds while maintaining high capacity,
- greater technical standardization, including comprehensive, line-wide control and traffic management systems, as well as power supply and diagnostics.

Despite the creation of an autonomous infrastructure network dedicated only to HSR, France has effectively connected high-speed rail with airports, regional rail services, and urban transport. An example is the TGV station at Charles de Gaulle Airport in Paris, which enables quick transfers between train and plane, or the integrated transport hubs in Lyon and Lille, where convenient transfers to regional trains are provided.

Many of the described experiences in the development of the French HSR network can be utilized and adapted to Polish conditions. France, as a pioneer of European high-speed rail, also has the longest experience in operating such a system. An analysis of French experiences allows for the identification of strategies that can assist Poland in effectively planning and developing modern railway infrastructure. Elements worth analyzing in this regard should include:

- the construction of separate tracks for HSR trains on entirely new routes,
- the separation of HSR traffic from freight and regional traffic,
- the implementation of modern traffic control systems that increase the capacity of routes.

A very valuable conclusion from the operation of French HSR is the confirmation of the possibility of effectively capturing passengers from other transport sectors. High-speed rail indeed represents a real alternative to aviation and road transport. As a result, in efforts to decarbonize the transport sector, it is preferred, among other things, through administrative bans on launching domestic flights on routes with a travel time of 2.5 hours by train.

French experiences also indicate that new high-speed lines should be planned in conjunction with regional and urban transport and guarantee easy, intuitive transfers. According to this principle, railway hubs such as Warsaw, Łódź, Poznań, and Wrocław should be adapted to handle HSR traffic, which requires the modernization of stations and improvement of their connections with public transport.

In terms of sources and mechanisms for financing the development of the Polish HSR network, it would be worth analyzing the significant involvement of the French state during the construction phase of the system and the promotion of development around the project of industries providing the necessary infrastructure, technological, and rolling stock solutions. In this context, the relatively rare public-private partnership instrument, which has supported investments in HSR infrastructure in this country since the 1990s, is also interesting.

Germany

Germany, alongside France, is one of the European leaders in the development of high-speed rail. The first ICE (Intercity-Express) line was opened in 1991 on the Hamburg–Frankfurt–Munich route. However, the development of high-speed rail in Germany was based on different assumptions than in France. The ICE system operates on a hybrid network instead of building entirely new, separated high-speed lines. High-speed trains here utilize both new infrastructure and modernized conventional routes (Nash, 2015). Currently, the German HSR network encompasses over 1,600 km of new lines, with trains reaching speeds of up to 300 km/h.

From the beginning, the ICE system was designed to be compatible with the existing infrastructure. This strategy has allowed the German high-speed rail to be effectively integrated with the existing railway system, enabling service to a large number of cities and regions.

One of the main elements of the German HSR development strategy is the lack of necessity to build separate railway lines along the entire route. Unlike in France, where TGV trains operate almost exclusively on dedicated tracks, in Germany, ICE trains use both HSR sections and conventional lines. Instead of creating separate corridors, the flexibility and operational integration of the existing and new network are utilized. An example of this is the Berlin–Munich line, where ICE trains operate on both high-speed sections (e.g., Berlin–Erfurt) and modernized conventional routes (Erfurt–Munich).

The benefits resulting from the hybrid model of the HSR network adopted in Germany include lower construction costs, stemming from the use of shared sections, and a reduction in construction costs and spatial conflicts in urbanized areas and ecologically valuable regions. Avoiding full separation of traffic allows for better utilization of existing infrastructure and the creation of a more extensive network of served routes, thus improving accessibility to medium and small centers. The model, in which ICE trains also operate on regional lines, also means the possibility of optimizing the connection network, greater operational flexibility, and a significant increase in the number of passengers served by the system.

The planning, construction, and operation model of the German HSR network leads to a very deep integration of long-distance rail with regional and urban traffic. ICE trains do not replace regional and interregional connections but complement their offerings. As a result, the system is coherent and has a nationwide character. This means that not only large stations serve as transfer hubs, but also medium-sized ones, and in selected cases, even small ones. Additionally, ICE trains operate at regular intervals, which improves the clarity of the timetable and the possibility of linking them with other rail connections. Regularity significantly facilitates the optimization of transfers and the integration of the system. This effect is further strengthened by a unified ticketing system, which allows passengers to flexibly combine journeys using various modes of transport.

The German HSR model can serve as a significant reference point for Poland, especially when seeking the shape and character of the target connection network. The solutions of our western neighbors may prove to be a more realistic and effective model than the French system, as they assume gradual network development, operational flexibility, and better integration with existing infrastructure. It is also worth noting that the German model better corresponds to the structure of our settlement network, which is more similar to the German than the French one. At the same time, it should be recognized that the implementation of the German model is not possible without the construction of new system elements. Poland lacks dedicated high-speed lines, and the current investments, which focus on improving the parameters of existing routes, cannot ensure speeds higher than 250 km/h.

German experiences can also be utilized in the development phase of the Polish HSR project. For example, on the Warsaw–Wrocław route, where initially HSR trains may use segments of new and existing lines, and ultimately utilize new dedicated sections.

Poland can benefit from Germany's experiences, including:

- staging the construction of high-speed rail and connecting new and deeply modernized sections,
- full integration of HSR with regional and urban rail and preparing a network of integrated transfer hubs,
- synchronization of timetables and tariff integration of high-speed and conventional rail,
- flexibility in creating connections for new infrastructure and linking HSR lines with existing routes.

It is also important to emphasize that the German HSR network was designed as part of a comprehensive transport system. A problem for Polish railways, in addition to infrastructural deficiencies, is indeed the deep disintegration of the system. The network of long-distance connections in many regions is not coordinated with regional connections. Utilizing German experiences may therefore provide an opportunity for a profound revision of thinking about the functioning of transfer hubs and the integration of schedules and tariffs of various types of connections.

Italy

Italy, like Germany, has adopted a hybrid approach to the construction of high-speed rail. This means that the Alta Velocità system utilizes both newly constructed high-speed lines (AV) and modernized conventional lines adapted for higher speeds.

The main difference between the mentioned models is that in Italy, the dedicated HSR infrastructure creates complete transport corridors – for example, Milan–Rome–Naples, while the modernization of existing routes ensures their extension, such as Turin–Venice. However, the varied nature of the network means that the speed of 300 km/h is not uniform, and trains only achieve it on lines built from scratch.

What fundamentally distinguishes the Italian model from the French and German ones is the open access to the HSR network and its availability to multiple carriers. Market liberalization contributes to an increase in the number of connections and enables competition within the rail sector. On HSR routes, there are two operators: the state-owned Trenitalia, which operates Frecciarossa trains, and Nuovo Trasporto Viaggiatori S.p.A., offering services under the Italo brand. Both companies compete for the same market and both report an increase in passenger numbers. Importantly, the competition introduced in 2022 did not cause the previous monopolist to lose passengers. Although its market share dropped from 100% to 71%, it still recorded an increase in passenger numbers. Experiences from the operation of the Italian HSR network indicate that railways gain at the expense of other modes of transport – primarily road and air. The effects of market liberalization in Italy's HSR have resulted in an 80% increase in passenger numbers due to internal competition and a reduction in ticket prices by up to 40%. The quality of services has improved – higher service standards and a greater offer of trains (ProKolej 2022).

From Poland's perspective, the Italian experiences in planning, constructing, and operating the HSR network confirm that the system does not require a complete network of new lines, and the key element of success is an attractive travel time and high quality and competitiveness of services. The benefits resulting from the Italian model are, like in Germany, lower construction costs and broader service availability. In addition to the advantages stemming from the hybrid model of construction and modernization of infrastructure and guidelines for integration with regional and air traffic, a point for detailed analysis is the issue of open access to the network. In many visions and concepts, the Polish HSR network is perceived as a centralized project, operated solely by PKP Intercity. However, analyzing the Italian experiences clearly shows the potential resulting from increasing the number of carriers. This tool not only allows for raising the quality and diversity of offered services but, above all, increases the customer base. This is due to the fact that competition forces the rationalization of ticket prices and the acquisition of new passengers who will fill trains operating with high frequency.

Spain

Spain, although it began constructing HSR infrastructure relatively late (the first AVE – Alta Velocidad Española – line was opened in 1992), currently has a network of over 4,000 km and is the leader in Europe in this regard (UIC, 2022). The Spanish model is characterized by dynamic expansion, a high degree of funding from European Union sources, and a strategy of building new, dedicated HSR lines instead of modernizing existing routes.

Unlike Germany or Italy, which integrated high-speed rail with the existing network, Spain opted to build entirely new HSR lines, independent of traditional railway infrastructure. This was primarily due to the decision to use the European standard gauge. The conventional Spanish network has an Iberian gauge (1668 mm), while the new HSR network was built to the European standard (1435 mm).

The result of constructing a new, autonomous HSR system is the lack of necessity to share tracks with freight or regional traffic, thus concentrating on the parameters necessary for high-speed movement. This means the possibility of increasing speeds. Dedicated HSR lines also offer very high capacity and thus the ability to operate a greater number of high-speed trains.

A characteristic feature of the Spanish HSR system is also the way investments are financed. While in France, Germany, and Italy, infrastructure was primarily built using national funds, Spain financed even 50-60% of the costs of high-speed rail construction through European Union funds. This was possible because the Spanish HSR project was primarily treated as a tool for reducing regional inequalities and promoting European integration. Fast connections between remote regions, such as Andalusia, Galicia, or Castilla-La Mancha, were intended to reduce their transport isolation and open them up to new investments. The new rail connections shortened travel times by over 50%, which increased the mobility of residents, providing better access to education and job markets in developed regions. At the same time, it improved the accessibility and tourist attractiveness of the regions served by HSR, contributing to their increased popularity, development, and influx of investments. Moreover, the adoption of the European standard gauge was indicated as a solution aimed at technical integration with the French network and, through it, with the rest of Europe.

Thanks to fast travel times and convenient connections, high-speed rail has become more competitive than domestic flights. HSR trains effectively captured passengers from domestic aviation on routes where high-speed rail was introduced.

Spain, like Italy, decided to open HSR infrastructure to competition. The liberalization of this market began in 2013 as part of a broad reform program aimed at improving service quality and better utilizing the effects of investments. As a result, new companies emerged to compete with the state carrier RENFE, such as Ouigo (a subsidiary of the French SNCF) and the Irish Iryo. One of the successes of the liberalization of the HSR market in Spain was the increased availability of services and, consequently, the number of passengers served by the system. This was contributed not only by lower ticket prices but also by greater flexibility and diversity of the offer, an increase in the number of connections, and additional rolling stock investments. Carriers, under competitive pressure, offered attractive promotions, loyalty packages, and accompanying services. As a result, the Spanish HSR network has become an example of a successful market transformation and a success in terms of both increased competitiveness and service quality.

Poland, like Spain, is relatively late in inaugurating the construction of a completely new HSR system and can therefore compare and utilize best practices from other European markets. The Spanish high-speed rail model provides guidance in this regard regarding planning, financing, and organizing the network. Key points include:

- the construction of dedicated lines and maximizing the effects resulting from the separation of fast train traffic from other traffic,
- maximizing engagement and utilization of EU funds – especially from competitive sources, such as the Connecting Europe Facility instrument,
- using the HSR project as a tool to support regional development and European integration,
- introducing competition as a tool to intensify traffic and innovation in transport offerings.

Spain has proven that high-speed rail can be a key element of a country's economic and social development. Poland, as the largest beneficiary of EU funds, has the opportunity to follow the same path and utilize a financing model similar to that of Spain. To this end, it is essential to emphasize the role of HSR infrastructure in the integration and development of the country and in improving the accessibility of less developed regions located on the external and internal peripheries. At the same time, a key element of network planning should also be the perspective of integrating the Polish and European HSR networks, especially at the southern and western borders. The international dimension should also be strengthened by projects such as Rail Baltica or connections towards Ukraine. By implementing Spanish experiences, it is possible to build a modern HSR system that will support both regional and international integration.

A valuable insight for the Polish high-speed rail project is also the success of the liberalization of the high-speed rail market in Spain. The process, which led to the expected increase in competitiveness, lower prices, and improved service quality, has also become a tool for intensifying the use of infrastructure. Thus, it strengthened the positive impact of HSR on the economy, the mobility of residents, and the accessibility and tourist attractiveness.

Analysis of Challenges in the Development of High-Speed Rail in Poland

One of the fundamental limitations in the development of high-speed rail in Poland is financial issues. The construction of new HSR lines requires multi-billion investments, which poses a significant challenge for the state budget (Nash, 2015). Support from European Union funds is crucial here, as it previously enabled the dynamic expansion of road infrastructure. Utilizing a similar funding model could accelerate the implementation of planned rail investments.

Additionally, managing infrastructure projects in Poland is characterized by high bureaucratization and lengthy administrative procedures. Compared to Spain or France, where HSR lines were built within 4-5 years, in Poland, decision-making and implementation processes take significantly longer (Albalate & Bel, 2012).

The effective implementation of high-speed rail requires its integration with the conventional railway system and public transport (UIC, 2018). Examples from France and Germany show that the success of high-speed rail depends not only on technical parameters but also on the quality of connections with the regional and local network. In Poland, a key element will be the coordination of timetables, the construction of transfer hubs, and the development of ticketing systems that enable easy connections between different modes of transport.

On the other hand, the experiences of Italy and Spain indicate the opportunities presented by market opening and the intensification of transport services accompanying competition among carriers. In this regard, a complementary element to the Polish HSR project should be transparent and flexible regulations that allow market access while ensuring high standards of safety and service quality. This process will require consideration of the specifics of the Polish market, as well as careful planning at all stages of project implementation to ensure its effectiveness in terms of the scale of transport services provided and economic benefits.

It should also not be forgotten that the biggest competitor to high-speed rail in Poland is road transport. Passenger cars account for over 80% of journeys over distances greater than 100 km (Eurostat, 2022). The experiences of countries such as France, Germany, Italy, and Spain show that operational speed and the associated travel time are just one aspect. However, there are many more elements that contribute to the success of HSR. At the planning and construction level of the transport offer, conditions such as financing possibilities and structure, the shape of the existing transport network, the level of railway competitiveness, and the expectations and role of the HSR system are also very important.

Summary and Conclusions

Poland is currently at a crucial moment in the development of railway infrastructure. The implementation of high-speed rail requires a strategic approach that includes effective financing, optimization of investment processes, and integration with the existing transport network. Therefore, the most important challenge is the effective preparation and execution of this project.

An analysis of the experiences of France, Germany, Italy, and Spain indicates the positive economic and environmental effects of implementing and operating a high-speed rail system. It also highlights somewhat different planning and operational models of individual HSR systems. Poland is currently at a key moment in the development of railway infrastructure. The implementation of HSR requires a strategic approach that includes effective financing, optimization of investment processes, and integration with the existing transport network. Experiences from other countries indicate that the development of HSR contributes to economic growth, improved mobility for residents, and reduced CO_2 emissions. A fundamental factor determining the success of the process remains the implementation of effective project management mechanisms and ensuring a stable source of funding, which by 2035 could enable Poland to achieve transport standards comparable to those of Western European countries.◀

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Railway Standards in standardisation and legal railway environment

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Abstract: CPK Railway Standards requirements in selected technical areas were presented during International Scientific and Technical Conference 'High Speed Railway Development in Poland'. Those standards comprise thirty-two volumes. Most users read them as a set of requirements in their area of interest. However, it is worth seeing them in a broader perspective. This is what this article is about.

Keywords: *High speed railways (HSR); HSR legal regulations; Standardisation; HSR technical standartds*

Introduction

From the very beginnings of railways, due to the technical characteristics of this mode of transport, railway companies—and soon after, national railways—adopted documents that meticulously regulated their operations. The strict adherence by employees of various departments (such as track maintenance, signalling, and operations) to clearly and precisely formulated instructions ensured the necessary relationships and interdependencies between different solutions, such as the interaction between the rail's running surface and the wheel's tread and flange.

It should be noted, however, that national railways in Europe have not existed for many years. Numerous passenger operators have emerged, along with an even greater number of freight operators and infrastructure managers who provide track access to trains. Freight transport, in particular, now frequently crosses borders on a large scale, moving beyond the boundaries of former national railway networks.

From operators' and infrastructure managers' instructions to the concept of a common market

Both railway operators and infrastructure managers have their own instructions regulating numerous aspects of railway operations. These cover a broad spectrum of activities, from detailed procedures for staff under normal and degraded operating conditions, maintenance rules for specific groups and types of technical solutions, and safety protocols for track and rolling stock work, to the principles of collecting, storing, and analysing operational and maintenance data.

There was a time when national authorities were formally obliged to review and approve the instructions issued by railway operators and infrastructure managers to ensure the coherence of the railway system. However, the sheer volume of such documents and the authorities' lack of hands-on operational experience led to the delegation of this responsibility to infrastructure managers and operators themselves. In most cases, infrastructure managers, through network regulations or contractual obligations, require operators to strictly comply with the instructions in force on a given network. Naturally, this does not eliminate operators' own instructions, nor does it override local or temporary regulations. The large number of applicable documents necessitates not only initial staff training before they are permitted to work but also continuous updates and improvement of their knowledge and skills. Among the tools used for this purpose are so-called periodic briefings.

In a few countries, infrastructure managers and operators have established joint organisations responsible for drafting, adopting, and improving regulations applicable to all entities, as well as for analysing the impact of their implementation. However, even such an approach does not ensure the level of railway consistency required for seamless cross-border operations. Since the nineteenth century and throughout much of the twentieth century, national railways were deliberately designed with technical differences to create barriers that would prevent neighbouring countries from using rail networks for military purposes. As a result, various elements of railway infrastructure and operations developed divergently, including different track gauges, loading gauges, traction power systems, pantograph geometries and materials, signalling systems (including signal aspects), and electromagnetic interference and immunity requirements. Another significant factor contributing to these differences was the long-standing practice of supporting domestic industries. Railway procurement constitutes a major sector, significantly impacting national economies, including GDP and employment. However, this localised approach to railway technical solutions has become an obstacle to the European vision of a single market for railway products and services, as well as the broader implementation of the four fundamental freedoms across Europe. It was recognised that ensuring the following aspects for railways was essential:

- free movement of goods, meaning that the same technical solutions should be applicable across different countries, without the need for separate approvals in each nation,
- free movement of services, allowing projects and work related to railway construction, modernisation, and operation to be carried out in any country without restrictions,
- free movement of people, reducing or eliminating barriers to recognising professional qualifications and authorisations obtained in one country for work in another,
- free movement of capital, removing financial and tax-related barriers between countries.

These principles were introduced to facilitate a unified railway market covering the entire European Union, as well as other European Economic Area countries and Switzerland, which have adopted EU railway regulations.

CEN, CENELEC, ETSI, and PKN Standards and UIC and OSJD Regulations

The European standards system, embedded in EU law, serves as a solution for harmonising technical regulations under the common market principles. Standards had existed before but were largely national in scope. Last year, the Polish Committee for Standardisation (PKN) celebrated its centenary. However, for over two decades, the work and documents adopted by standardisation committees have had an international character.

European standardisation organisations include CEN, responsible mainly for standards in mechanics, materials, and testing; CENELEC, focusing on electrotechnical and electronic standards; and ETSI, covering telecommunications. These organisations receive mandates from the European Commission to develop and agree on standards, which are then published in the EU's Official Journal as harmonised standards for the common market. In the railway sector, standards are developed by CEN TC 256, CENELEC TC 9X, and ETSI RP.

A prerequisite for joining the EU is full membership in CEN, CENELEC, and ETSI, which requires the adoption of EN standards into national collections through translation or recognition. For instance, Poland became a full member of CEN, CENELEC, and ETSI on 1 January 2004, ahead of its accession to the European Communities, later transformed into the European Union, on 1 May 2004.

Cross-border railway transport had, of course, existed earlier. At least three international/intergovernmental organisations have regulated technical, operational, formal, and legal aspects of railway transport:

1. The International Union of Railways (UIC) – A global organisation established in 1922 through cooperation among national railways. UIC developed hundreds of UIC leaflets (fiches). Today, these are no longer binding in Europe. Instead, European standardisation organisations (CEN, CENELEC, ETSI) hold the right to incorporate them into standards. However, UIC continues to share technical knowledge and develop documents under the International Railway Solutions (UIC IRS) framework, providing best practice reviews. UIC also serves as a research and development platform for emerging railway technologies.
2. The Organisation for Co-operation between Railways (OSJD) – A technical railway organisation originally formed as a legacy of the Warsaw Pact. It primarily represents railways operating on the 1520 mm gauge, such as Russia's, but also includes China, where the standard gauge is 1435 mm, like in most of Europe. OSJD maintains and continues to develop OSJD leaflets, which are essential for cross-border operations in Eastern Europe and Asia. Some UIC/OSJD leaflets have been harmonised, such as those governing consignment notes. Unlike UIC, which does not impose legal obligations on governments, OSJD is both an international and intergovernmental organisation, meaning that it can establish binding legal regulations for its members.
3. The Convention concerning International Carriage by Rail (COTIF) – An intergovernmental organisation covering not only all EU countries but also Eastern European, Middle Eastern, and North African states. COTIF regulates international railway transport through a series of extensive annexes to the convention. One example is the RID regulations, which classify dangerous goods transported by rail and set out stringent requirements for their securing and labelling.

The European Commission is a COTIF member and closely collaborates with UIC. Discussions on cooperation with OSJD have been ongoing for years, although some of OSJD's responsibilities have been transferred to the Council for Railway Transport of the Commonwealth of Independent States (CIS) following decisions by the Russian authorities.

Technical Interoperability Specifications TSI

The common market for many types of products relies on linking European Parliament legislation with harmonised standards, such as those for toys regulated by CEN and CENELEC standards. However, due to the complexity of railway transport, this approach was deemed impractical. It was also recognised that achieving a fully integrated railway market, allowing for the free movement of goods, services, people, and capital within the EU, required the development, adoption, and continuous improvement of Technical Specifications for Interoperability (TSI). This concept was first introduced for high-speed railways and later extended to conventional rail in 2004.

There are currently eleven extensive TSI specifications adopted by the European Commission. These regulations define requirements for five structural and three operational subsystems that collectively form the EU railway system. Structural subsystems include infrastructure, energy, and trackside control-command (INF, ENE, CCT), managed by infrastructure operators, while rolling stock and onboard control-command (RST, CCO) constitute railway vehicles.

The TSI specifications define many detailed requirements; however, in many aspects, they refer to the provisions of CEN, CENELEC, and ETSI standards, making them mandatory. Few standards are referenced in their entirety in this manner. Most provisions in the standards form the basis for meeting the essential requirements specified in the annex to the directive on railway interoperability. At present, one hundred and ninety-seven European standards have been harmonised with the TSI specifications. The TSI specifications are also supplemented by specifications adopted by the European Union Agency for Railways and NBRail recommendations, jointly adopted by Notified Bodies (NoBos), which are formally authorised to confirm the compliance of technical solutions with European requirements.

Certain national requirements remain in force within narrow scopes. It is also necessary to verify the compliance of new interoperable rolling stock with existing non-interoperable railway lines. All of this falls within the remit of Designated Bodies (DeBos), which receive their authorisation from the relevant authorities of individual states. The retention of certain, increasingly fewer, national requirements results from the need to maintain the coherence of networks and rolling stock at the national level, given the long operational lifespan of railway lines—one hundred years or more—and rolling stock—thirty years or more. Such national coherence is sometimes referred to as intraoperability, by analogy with interoperability. It is akin to global coherence—such as the internet—and coherence at the corporate or company level—such as an intranet. Both have their role and are necessary.

Technical standards developed by the Railway Institute

Even broader, yet still highly detailed, are the multi-volume railway standards developed by the Railway Institute. The first standards, prepared in 2001–2002, concerned increasing speed on the Central Railway Mainline. The subsequent standards, which are still referenced in many tenders for railway investments by PKP Polskie Linie Kolejowe, were developed in 2008–2009 and are dedicated to the modernisation of railway lines for speeds of up to 200 km/h. These standards comprise sixteen volumes:

Volume I – Track infrastructure
Volume II – Railway line clearance gauge
Volume III – Railway engineering structures
Volume IV – Electric traction equipment
Volume V – Non-traction power engineering
Volume VI – Signalling, control, and traffic management
Volume VII – Telecommunications
Volume VIII – Detection of rolling stock emergency conditions
Volume IX – Electromagnetic compatibility
Volume X – Level crossings, parallel roads
Volume XI – Structures
Volume XII – Small architecture, identification systems
Volume XIII – Buildings
Volume XIV – Crossings and railway line protection
Volume XV – Environmental protection
Volume XVI – Rolling stock requirements

Most recently, in the years 2021–2023, the Technical Standards – Detailed technical conditions for the construction of the railway infrastructure of the CPK were developed. These standards are referenced in the tender documents of CPK. They are broader in scope, dedicated to the construction of new infrastructure rather than the modernisation of existing railway lines, and comprise thirty-two volumes:

Volume A – Introduction to CPK Railway Standards
Volume I.1 – Railway track – geometrical layouts
Volume I.2 – Railway track – construction of civil structures
Volume I.3 – Railway track – drainage of the track layout
Volume I.4 – Railway track – structure gauge
Volume I.5 – Railway track – geotechnical investigations and design
Volume II.1 – Overhead catenary system and traction power supply
Volume II.2 – 3 kV DC overhead catenary and traction power supply
Volume III.1 – Engineering structures
Volume III.2 – Tunnels
Volume IV – Non-traction power engineering
Volume V.1 – Non-public roads
Volume V.2 – Public roads
Volume VI.1 – Control command and signalling – basic equipment
Volume VI.2 – Control command and signalling – European Train Control System (ETCS)
Volume VII.1 – Fixed and wireless communication systems and data transmission
Volume VII.2 – Telecommunication systems and telematics
Volume VII.3 – Devices for the detection of rolling stock failure conditions (DSAT)
Volume VIII.1 – Station and railway station buildings
Volume VIII.2 – Technical buildings
Volume VIII.3 – Structures
Volume VIII.4 – Structural landscaping
Volume IX – Measures to minimise environmen-

tal impact
Volume X – Conflicts with external networks
Volume XI – Electromagnetic compatibility (EMC)
Volume XII – Railway line guard
Volume XIII – Technical support facilities
Volume XIV – Health and safety support systems for people and property
Volume XV – Survey control
Volume XVI – Rolling stock
Volume XVII – Automatic baggage check-in systems
Volume XVIII – Consistency requirements: security, protection, and cybersecurity

Both the standards used by PKP PLK S.A. and those applied by CPK sp. z o.o. are fully publicly available.

The CPK railway standards have been defined in a structure similar to that of the Technical Specifications for Interoperability. In defining and referencing the requirements, reference was therefore made to the essential requirements set out in the European directive on railway interoperability, as well as to the basic requirements defined in the European regulation on construction products. Additionally, following the same patterns, 'four general requirements additionally defined for CPK railway infrastructure' have been specified as follows:

1. Focus on the needs of the economy
1.1. The infrastructure should include track layouts dedicated to freight transport, adapted for vehicles with a clearance gauge appropriate for both European and Asian tracks.
1.2. Freight transport service systems must be adapted to the needs of specific types of transport (e.g. container transhipment, pumping of tanker contents, handling of non-standard intermodal units).
2. Focus on passenger needs
2.1. Railway stations, stops, and terminals should have a standardised system for providing passengers with all information related to the use of both railway and other interconnected transport services. This system should ensure the correct dissemination of all essential information both under normal operating conditions and in disrupted situations (e.g. service disruptions, railway incidents, and accidents).
2.2. Railway stations, stops, and terminals should be equipped with devices and systems for detecting and monitoring threats to passengers (e.g. emergency telephones, CCTV monitoring, systems for detecting passengers near the platform edge when trains approach).
2.3. Railway stations, stops, and terminals should be equipped with passenger health support devices and systems, particularly AED systems.
2.4. Adequate evacuation measures and systems to prevent panic (e.g. public address systems) must be ensured.
2.5. Railway stations, stops, and terminals should provide a suitable level of both basic services (e.g. ticket sales) and complementary services (e.g. the availability of food, newspapers, books, or the possibility of having a meal before or after the journey).
3. Focus on the needs of railway operators
3.1. Rolling stock service systems should be adapted to the needs of various operators under normal operating conditions (e.g. toilet emptying, water refilling, replenishment of sand in sanding systems).
3.2. Adequate measures must be in place for emergency support services for operators in disrupted conditions (e.g. communication facilities, emergency semi-couplers).
4. Compatibility with railway infrastructure connected to the CPK railway infrastructure
4.1. It is essential to ensure the compatibility of the CPK railway infrastructure with other railway infrastructure to which it will be connected (e.g. through appropriate sections separating traction power supply systems).

At the same time, it has been noted that documents defining technical conditions for the construction (as well as modernisation, reconstruction, or operational safety) of railway infrastructure have different legal statuses. Typically, five levels of regulation are distinguished, ranging from directive provisions to infrastructure manager instructions. These documents are usually presented in a pyramid format. This pyramid representation also marks the scope covered by the individual sectoral volumes of the CPK railway standards, as shown in the diagram below.

1. Scope of the Technical Standards and Detailed Technical Conditions for the Construction of the Railway Infrastructure of the CPK Source: Volume A, CPK Standards

It has been noted that, concerning the different levels, the CPK railway standards are structured as follows:

LEVEL I – Railway directives, regulation on construction products
Volume A – repeats the essential and basic requirements and supplements them with general requirements for CPK.
Sectoral volumes – contain tables indicating the relationship to specific requirements.
LEVEL II – TSI specifications and CSM-RA regulation
Sectoral volumes – repeat the requirements of individual TSI specifications.
LEVEL III – European standards and European specifications
Sectoral volumes – indicate both the standards and specifications that are legally mandatory and those whose application remains voluntary under the law but is imposed by CPK railway standards.
LEVEL IV – Industry standards
Sectoral volumes – cite or reference selected requirements only if they are necessary to ensure compliance with both essential and/or supplementary general requirements for CPK infrastructure.
LEVEL V – Internal instructions
Sectoral volumes – generally do not include internal instructions.

The detailed technical conditions for the construction of CPK railway infrastructure, as presented in the sectoral volumes, are structured by subject matter without division based on the levels of requirement sources. This ensures clarity of requirements. Nevertheless, mandatory requirements under TSI specifications are framed, indicating their source documents. Additionally, in a tabular format, specific detailed technical conditions have been linked to the essential, basic, and general requirements for CPK railway infrastructure.

Conclusion

At the HSR conference in Łódź, out of fifty presentations, seven addressed selected areas of requirements from the CPK railway standards—requirements for tunnels, railway track, traction power supply, control systems, communication, rolling stock requirements resulting from infrastructure characteristics, as well as railway interoperability and intraoperability. However, the standards encompass a much broader scope of requirements.

This article illustrates how to perceive the role of technical standards. It deliberately omits both the key requirements presented in the aforementioned areas and several volumes that were not discussed at the conference. This is intentional, as the standards are publicly available and can be accessed without restrictions. However, obtaining a broader perspective on standards in the context of legal regulations and standardisation is considerably more challenging. ◀

Access to public procurement for companies from third countries – revolution or evolution?

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Abstract: The article concerns the Court of Justice of the European Union judgment issued on 22 October 2024 in Case C-653/22 (the Kolin case), which contains theses important for EU public procurement practice. The ruling sheds new light on the participation in public tenders of entities from countries other than EU member states, that have not concluded international agreements with the European Union guaranteeing mutual and equal access to public procurement markets. In particular, the judgment issued in the Kolin case points to the important role of contracting authorities, who can restrict participation of entities from the abovementioned countries in a given public procurement procedure in Poland or other EU member state.

Keywords: *Court of Justice of the European Union; Public tenders; Third party access; Public procurement directives*

Introduction

In recent weeks, the judgment of the Court of Justice of the European Union (**CJEU**) issued on 22 October 2024 in the case of Kolin Inşaat Turizm Sanayi ve Ticaret (C-652/22), hereinafter referred to as the '**Kolin case judgment**,' has sparked considerable debate.

Rightly so, as its key findings regarding the differentiated treatment of companies from certain third countries in public procurement procedures could lead to a shift in approach, both among contracting authorities and the Polish legislator, concerning the participation of firms from these countries in public tenders in Poland. In light of the CJEU's ruling, Polish contracting authorities may entirely exclude offers from contractors based in countries such as Turkey, China, or India from public procurement procedures or apply different evaluation criteria, not treating them on an equal footing with companies from EU Member States and entities from non-EU countries that are parties to relevant international agreements with the EU. As a result, much will depend on individual contracting authorities and the specific rules they establish for participation in procurement procedures.

This topic is highly relevant not only to the railway sector but also to the broader transport industry, where companies from non-EU countries—including those without international agreements with the EU guaranteeing reciprocal and equal access to public procurement markets—compete for public contracts in Poland (and other EU Member States). These companies frequently appear in public tenders as third-party entities, providing resources to contractors (bidders) to help them meet participation requirements or selection criteria.

In the context of high-speed rail (HSR) projects in Poland, the Kolin case judgment may be particularly significant, given that Asian countries, especially China, have accumulated substantial expertise in this field, boasting the world's longest HSR network. Turkey is also a major player in this market.

Third-country entities: who does the Kolin case judgment apply to?

In the Kolin case judgment, the Court of Justice of the European Union **distinguished between third countries** that are not members of the European Union but have concluded relevant international agreements with the EU (specifically, agreements guaranteeing—on the basis of reciprocity and equality—access for EU contractors to public procurement markets in those third countries, as well as access for contractors from those third countries to public procurement markets in the EU) and third countries that have not concluded such agreements with the European Union.

The first group of countries primarily includes third countries that are signatories to the Agreement on Government Procurement (GPA), concluded within the framework of the World Trade Organization (WTO). These include, among others, Canada, Israel, Japan, South Korea, Switzerland, Ukraine, and the United States. Additionally, this group includes third countries that have signed bilateral international agreements with the European Union, which provide enhanced access to each other's public procurement markets, such as Canada, Japan, and the United Kingdom.

Contractors from these countries are guaranteed treatment no less favourable than EU contractors in EU public procurement markets, as reflected in EU public procurement directives. Regarding these countries, the CJEU in the Kolin case judgment reaffirmed that the right to 'no less favourable treatment' granted to contractors from these third countries means that they may invoke the provisions of EU public procurement directives.

The second group of countries consists of **third countries that have not concluded any agreements with the EU that formally open public procurement markets on a reciprocal basis**, such as Turkey, China, or India. The participation of entities from these countries in EU public procurement procedures is the subject of the CJEU's reasoning in the Kolin case judgment.

The Kolin case judgment – factual background

The Kolin case judgment concerns a public tender for railway infrastructure construction worth approximately €300 million, conducted in Croatia by the national railway infrastructure manager. In this tender, a Turkish entity challenged the selection of a competing bid submitted by a consortium of three companies from the Strabag group. The case was brought before a Croatian court, which raised doubts about whether the contracting authority's decision to award the contract to the winning consortium complied with Directive 2014/25/EU on public procurement in the utilities sector [1]. Consequently, the court referred preliminary questions to the CJEU, specifically regarding documents proving compliance with participation requirements, which had been submitted to the contracting authority after the deadline for tenders had passed.

On this factual basis, the Advocate General—whose role is to provide independent and objective legal opinions on cases before the CJEU—raised concerns about whether the Croatian request for a preliminary ruling was admissible at all. The source of controversy lay in the fact that the plaintiff in the Croatian proceedings was a Turkish company, meaning a firm from a third country with which the EU has not concluded international agreements guaranteeing reciprocal and equal access to public procurement markets. The Advocate General's concerns focused on two key questions:

- Can contractors from third countries that have not concluded international public procurement agreements with the EU participate in public procurement procedures within the EU at all?
- If so, can Member States set the conditions for their participation in such procedures, or is this an exclusive competence of the EU?

Ultimately, as Turkey is a third country that is not a party to international agreements with the

EU guaranteeing reciprocal and equal access to public procurement markets, the CJEU declared the preliminary reference inadmissible and refused to answer the Croatian court's questions. However, the Court of Justice took the opportunity to analyse the situation of contractors from such third countries, presenting conclusions that fundamentally change the perspective on their participation in EU public tenders.

Access of contractors from third countries to public tenders

In the Kolin case judgment, the Court of Justice of the European Union (CJEU) ruled that **contractors from non-EU countries that have not concluded a relevant international agreement with the EU cannot** rely on EU public procurement directives **to claim equal treatment** of their bids alongside offers submitted by EU-based contractors or contractors from third countries that have signed such agreements with the EU.

The Court also held that the issue of access to public procurement procedures in EU Member States for contractors from third countries falls under the exclusive competence of the EU. As a result, Member States are not authorised to adopt general legislation in this area. In the absence of such an EU legal act, it is for the individual contracting authority to determine whether to allow a third-country contractor to participate in a public procurement procedure. Furthermore, the contracting authority may establish specific conditions in the procurement documents that reflect the objective differences in the status of such contractors.

Additionally, the CJEU emphasised that national authorities may not interpret national provisions transposing EU directives in such a way that they would automatically apply to contractors from third countries that have not signed an agreement with the EU. While it is conceivable that the treatment of such contractors should align with certain principles such as transparency and proportionality, any legal remedy available to a contractor seeking to challenge a contracting authority's breach of these principles would be considered exclusively under national law, not under EU law.

What is new in the Kolin case judgment?

Is the approach taken by the Court of Justice of the European Union (CJEU) in this judgment towards entities from non-EU countries that have not concluded international agreements with the EU guaranteeing reciprocal and equal access to public procurement markets surprising? Considering the evident evolution of the EU's stance, as well as EU policies and regulations emphasising the need for more balanced conditions based on reciprocity in relations with third countries, the conclusions drawn in the Kolin case judgment should not come as a surprise. A review of recent EU-level communications and legal acts confirms this trend.

As early as 24 July 2019, in the European Commission's guidelines on the participation of non-EU entities in the EU public procurement market [2], it was stated that **contractors from third countries** that have not concluded an international agreement with the EU providing for market access for EU-based contractors **should not be guaranteed equal access** to public procurement procedures within the EU. Three years later, on 29 August 2022, the EU Regulation on the access of third-country contractors [3] came into force, explicitly stating that the access of third-country contractors to EU public procurement markets falls within the scope of the EU's common commercial policy. This regulation empowers the European Commission to introduce **measures restricting access for third-country contractors to EU public procurement markets** (the International Procurement Instrument, IPI) by adjusting bid scoring or excluding offers where it is determined that third countries are engaging in measures or practices that disadvantage EU contractors. Subsequently, on 12 July 2023, the first provisions of the **Foreign Subsidies Regulation** (FSR) entered into force, introducing a broad set of legal instruments enabling the European Commission to counter market distortions within the EU's internal market caused by subsidies granted by non-EU countries.

Given the above guidelines and legal acts adopted at the EU level, the conclusions of the Kolin case judgment align with the clear trend observed in recent years towards establishing more balanced conditions based on reciprocity in relations with non-EU countries.

Can contractors from third countries participate in public tenders in the European Union?

This question was raised by the Advocate General in the opinion on the Kolin case, specifically in relation to contractors from third countries with which the EU has not concluded an international public procurement agreement. The Court of Justice of the European Union reached a fundamental conclusion that entities from third countries that are not signatories to such agreements or international arrangements **have no guaranteed right** to participate in EU public procurement procedures, and their access to the EU public procurement market may be restricted.

Although the CJEU's findings directly apply to the factual circumstances of the case, in which the contractor (bidder) was from Turkey, an important question arises: to what extent do these conclusions apply to the participation of firms from such third countries in procurement procedures in other configurations, for example, when they act as third-party entities providing resources to contractors or as subcontractors—in other words, whether their participation in such roles may also be restricted by the contracting authority.

Opinion of the Public Procurement Office

In information published on its official website [4], the Public Procurement Office outlined the key implications of the CJEU ruling for procedures conducted under the Polish Public Procurement Law:

First, **contracting authorities have the right to restrict access to public procurement for contractors from third countries** with which the European Union has not concluded an international agreement guaranteeing reciprocal and equal access to the public procurement market. Such restrictions may take the form of excluding these entities from participation in the procedure or differentiating the treatment of such entities in the procurement process, and these conditions should be clearly specified in the procurement documents.

Second, in the view of the Public Procurement Office, such restrictions are **always a decision of the contracting authority** in a given procedure. Contracting authorities may choose not to restrict access to public procurement for contractors from third countries, even if those countries have not concluded an international agreement with the EU guaranteeing reciprocal and equal access to the public procurement market.

Third, if a contracting authority decides to exclude contractors from third countries that have no international agreement with the EU guaranteeing reciprocal and equal access to the public procurement market, and this is specified in the procurement documents, then any **bid submitted by such a contractor will be subject to rejection**.

Conclusion

The Kolin case judgment will undoubtedly influence the practice of awarding public contracts in Poland. Time will tell to what extent Polish contracting authorities will make use of the right confirmed by the CJEU in this judgment, which allows for differentiated treatment of entities from non-EU third countries that have not concluded international agreements with the EU guaranteeing access to public procurement markets—meaning that these entities may be treated less favourably than others.

In procurement practice, there will certainly be a need to address numerous questions arising from this judgment, such as whether its conclusions also apply to third-party entities providing resources to contractors to meet participation requirements, or how the findings in the Kolin case affect the right of contractors from such third countries to seek legal remedies. It is also possible that the Polish legislator will introduce legislative amendments to the Public Procurement Law to clarify practical uncertainties resulting from this ruling. ◀

Source materials

[1] Directive 2014/25/EU of the European Parliament and of the Council of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC (OJ L 94, 28.3.2014).

[2] Communication from the Commission of 24 July 2019 — Guidance on the participation of third-country bidders and goods in the EU procurement market.

[3] Regulation (EU) 2022/1031 of the European Parliament and of the Council of 23 June 2022 on the access of third-country economic operators, goods and services to the Union's public procurement and concession markets and procedures supporting negotiations on access of Union economic operators, goods and services to the public procurement and concession markets of third countries (International Procurement Instrument – IPI) – (OJ L L 173, 30.6.2022, p. 1.

[4] Udział_wykonawców_z_państw_trzecich_w_świetle_wyroku_TSUE_w_sprawie_C-652_22 (1).pdf

Misleading the contracting authority and exclusion from the procurement procedure

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Abstract: The article describes cases in which a contractor may be excluded from a public procurement procedure based on Article 109(1)(8) and Article 109(1)(10) of the Public Procurement Law (Pzp) for misleading the contracting authority. Additionally, the article analyzes the practical challenges associated with the application of the self-cleaning procedure, whose effectiveness depends on the contractor's ability to continue competing in the public procurement market. The conclusion of the article emphasizes that, although misleading the contracting authority can result in serious consequences in the procurement process, the self-cleaning procedure provides a mechanism that allows the contractor to rectify the situation and restore credibility.

Keywords: *Exclusion from the procedurę, Misleading the Contracting Authority; Self-cleaning, article 109(1)(8) of the Public Procurement Law (PPL); Article 109(1)(10) of the Public Procurement Law (PPL)*

In the public procurement system, one of the key principles should be fair competition and transparency in the procedure. Misleading the contracting authority constitutes conduct by a contractor that violates these fundamental principles. However, as misleading the contracting authority is one of the most serious breaches a contractor can commit, it may primarily result in the exclusion of the contractor from the procedure. In Poland, this issue is regulated by the Act of 11 September 2019 – Public Procurement Law (Journal of Laws of 2024, item 1320, hereinafter referred to as the 'PPL'). The purpose of this article is to discuss the issue of excluding a contractor from a procedure for misleading the contracting authority, as well as the legal consequences of such conduct.

Pursuant to Article 109(1)(8) of the Public Procurement Law (PPL), the contracting authority may exclude from the procedure a contractor who, as a result of deliberate action or gross negligence, has misled the contracting authority when presenting information that they are not subject to exclusion, fulfil the conditions for participation in the procedure, or meet the selection criteria, where such misinformation could have had a significant impact on the decisions made by the contracting authority in the procurement procedure. The exclusion may also apply to a contractor who has concealed such information or is unable to provide the required evidentiary documents.

Additionally, pursuant to Article 109(1)(10) of the PPL, the contracting authority may exclude from the procedure a contractor who, as a result of recklessness or negligence, has provided misleading information, where such misinformation could have had a significant impact on the decisions made by the contracting authority in the procurement procedure.

Table 1 presents the differences between intentional and unintentional misleading of the contracting authority.

Misleading the Contracting Authority occurs when a contractor provides false information, leading the contracting authority to make decisions that are detrimental to the objectives of the public procurement procedure. In the context of public procurement, such situations may primarily involve:

1) False statements contained in documents submitted as part of the procedure, such as the European Single Procurement Document (ESPD);
2) Concealing material information that could influence the outcome of the procedure;
3) Providing incomplete data, for example, omitting significant details in the tender submission that could affect the evaluation of the contractor's offer.

Such actions may result in the exclusion of the contractor from the procedure, highlighting the importance of correctly and transparently presenting information.

In the infrastructure sector, where many contractors are based outside the Republic of Poland or even outside the European Union, an additional issue arises regarding the interpretation of legal provisions from a given country and whether they are applicable in a particular procurement procedure.

Judgment of the National Appeals Chamber of 26 September 2023 (KIO 2572/23, KIO 2574/23)

In the context of this analysis, it is worth referring to the judgment of the National Appeals Chamber (KIO) of 26 September 2023 (KIO 2572/23, KIO 2574/23), in which the Chamber examined issues relevant to this article. The KIO emphasised that gross negligence was not only the result of concealing information but also of the contractor's assumption that violations committed in the country where a consortium member was based had no bearing on a procurement procedure conducted in Poland. This misled the contracting authority into believing that there were no grounds for excluding the contractor, ultimately affecting the outcome of the procedure.

A consortium member whose offer was selected as the most advantageous in the procedure failed to inform the contracting authority when completing the ESPD form about administrative penalties imposed on the company for violations of environmental and labour law regulations in the country where it was based. Furthermore, in its statement regarding the validity of the information contained in the ESPD, the company declared that the information was up-to-date and truthful, acknowledging full awareness of the consequences of misleading the contracting authority.

In this context, it was crucial that the company was aware of the administrative penalties imposed on it, as evidenced by the documentation presented by the parties during the appeal proceedings, including a list of penalties and detailed information on administrative decisions. The contractor wrongly assumed that this information did not need to be disclosed, which, as the Chamber underlined, misled the contracting authority into believing that the contractor was not subject to exclusion from the procedure. The contracting authority's mistaken belief that the contractor was not subject to exclusion affected the outcome of the procedure, as evidenced by its decision to select the offer submitted by the Intercor Consortium as the most advantageous.

In the discussed judgment, the National Appeals Chamber (KIO) also emphasised the importance of the utmost diligence by contractors in completing the European Single Procurement Document (ESPD), which is a key document allowing the contracting authority to assess the contractor's credibility. The Chamber pointed out that the document is categorical in nature due to the significance of the statements made within it. If a contractor selects 'no' in the ESPD, it prevents the contracting authority from evaluating whether the contractor guarantees proper contract execution, even when a situation requiring disclosure exists. This, in effect, places the contractor in the role of 'judge in their own case.'

Another important issue raised by the KIO was that Article 109(3) of the Public Procure-

Tab. 1. *Differences between intentional and unintentional misleading of the contracting authority*

	Article 109(1)(8) of the PPL	Article 109(1)(10) of the PPL
Behaviour	- Misleading the contracting authority - Concealing information - Failure to provide the required evidentiary documents	- Misleading the contracting authority
Degree of culpability	- Intentional action - Gross negligence	- Recklessness - Negligence
Scope of the subject matter of the information provided	- Non-exclusion from the procedure - Fulfilment of the conditions for participation in the procedure - Compliance with the selection criteria	
Impact on the contracting authority's decision	- Significant	- Significant

ment Law (PPL), which allows for a waiver of exclusion if such exclusion would be clearly disproportionate, does not apply when the grounds for exclusion under Article 109(1)(8) of the PPL are met. This means that if a contractor misleads the contracting authority, they lose the possibility of avoiding exclusion on the grounds of disproportionality.

Another issue worth noting is that the National Appeals Chamber (KIO) also stated that in cases where the conditions under Article 109(1)(8) of the Public Procurement Law (PPL) are met, Article 109(3) of the PPL, which provides for the possibility of waiving exclusion if exclusion would be manifestly disproportionate, does not apply. This means that if a contractor misleads the contracting authority, there is no longer any basis for applying the mitigating measure under the PPL, that is, the possibility of waiving exclusion due to the manifest disproportionality of such a measure.

In other words, attempting to deceive the contracting authority results in a kind of 'penalty'—the loss of the right to avoid exclusion for other 'lesser' reasons.

False information provided by an entity supplying resources

Similar conclusions can be drawn from the judgment of the National Appeals Chamber of 2 August 2022 (KIO 1854/22), in which the Chamber found that a contractor relied on the capacity of a third-party entity to demonstrate compliance with participation requirements but failed to properly verify the claimed experience of that entity.

The Chamber stressed that reference letters obtained from the third-party entity, as well as conversations with its employees, were not sufficient to assess the actual scope of experience, particularly given that it is common practice for reference letters to contain only a general confirmation of the proper execution of a project with a specific name, without providing detailed information on the specific tasks carried out by the contractor.

According to the KIO, the contractor should have thoroughly examined the actual scope of work performed by the third-party entity, rather than relying solely on its assurances.

It should be emphasised that the Chamber considered the lack of such verification as recklessness and negligence, which resulted in misleading the contracting authority.

Moreover, it is worth noting that the Chamber stated that a contractor cannot replace one third-party entity with another if the contracting authority has already discovered the issue. The possibility of applying Article 122 of the PPL is only available if the contractor independently realises the mistake and takes corrective action before the contracting authority intervenes.

Exclusion period for the contractor

The period for which a contractor may be excluded depends on the nature of the violation and the grounds for exclusion applied. If the violation resulted from intentional misconduct, the exclusion period will be at its maximum, i.e. three years, as this demonstrates a deliberate attempt to undermine the integrity of the procedure. However, if the violation was due to recklessness or negligence, the exclusion period may be shorter—typically one year—especially if the contractor had no intention of misleading the contracting authority.

It is important to highlight that the decision to exclude a contractor and the length of the exclusion period should be proportionate to the severity of the violation and based on an objective analysis of evidence.

The exclusion of a contractor from the procurement procedure has far-reaching legal and financial consequences. The direct result of exclusion is the rejection of the contractor's bid or application.

Self-cleaning procedure

A contractor may mitigate the consequences of exclusion by applying the self-cleaning mechanism. Pursuant to Article 110(2) of the PPL, a contractor subject to exclusion may undertake corrective actions that could restore their eligibility to participate in the procedure. In order to do so, the contractor must demonstrate to the contracting authority that, despite the grounds for exclusion, they have fulfilled all three of the following conditions:

1. They have remedied or committed to remedy the damage caused by a criminal offence, an administrative offence, or their improper conduct, including through financial compensation;
2. They have provided a comprehensive explanation of the facts and circumstances related to the criminal offence, administrative offence, or improper conduct, as well as the damage caused, actively cooperating with the competent authorities, including law enforcement or the contracting authority;
3. They have implemented specific technical, organisational, and personnel measures appropriate to prevent further offences, administrative violations, or misconduct.

Tab. 2. *Relationship between exclusion and misleading the contracting authority*

Intentional Misleading	Unintentional Misleading
Article 111(1)(8) of the PPL	Article 111(1)(9) of the PPL
2 years from the date of the occurrence of the event constituting the basis for exclusion	**1 year** from the date of the occurrence of the event constituting the basis for exclusion

It should be emphasised that for self-cleaning to be effective, the contractor must prove that the corrective actions taken are appropriate and sufficient to eliminate the risk of repeated violations. In practice, this means that the contractor must submit evidence to the contracting authority showing that, for example, they have successfully reorganised internal procedures, implemented preventive and corrective systems, and repaired damage caused to the contracting authority. This position has been upheld by the National Appeals Chamber (KIO), including in its judgment of 14 March 2022 (case reference KIO 375/22), where the Chamber emphasised the requirement for the self-cleaning procedure to be genuine. The self-cleaning process cannot be merely superficial. It must fully and reliably meet the statutory requirements set out in Article 110(2) of the PPL. Only in this way can the purpose of the procedure be fulfilled, which, according to both EU and Polish legislators, is to ensure that similar situations do not occur in the future.

Importantly, it is the contracting authority that evaluates the adequacy of the self-cleaning measures submitted by the contractor. If, after analysing the corrective actions, the contracting authority deems them insufficient, the contractor remains excluded from the procedure. In other words, self-cleaning may convince one contracting authority but fail to convince another. The effectiveness and evaluation of self-cleaning measures depend on the specific circumstances and timing of the procurement procedure.

Thanks to the self-cleaning procedure, a contractor not only gains the opportunity to correct past mistakes but, by demonstrating genuine commitment to eliminating the consequences of their actions, can continue operating on an equal footing with other participants in the public procurement market.

In conclusion, misleading the contracting authority constitutes a serious violation of public procurement rules and may result in exclusion from the procedure under Article 109(1)(8) or Article 109(1)(10) of the PPL. These provisions are designed to ensure the fair conduct of public procurement procedures. However, the self-cleaning procedure provides contractors with the opportunity to mitigate the consequences of their actions by implementing effective corrective measures.

Safe foundations for High-Speed Rail

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Abstract: This article describes the current guidelines for geotechnical design of High-Speed Railways. Special attention is given to the aspects of dynamic stability of soil as a new technical issue. The Vibro Replacement technology is indicated as a reasonable soil improvement solution, allowing for the fulfillment of design requirements for railway track construction. Technical details of the Vibro Replacement implementation are provided. Examples of use of gravel columns for conventional railways in Poland and for High-Speed Railways outside the country's borders are described.

Keywords: *High-Speed Rail; Central Communication Port; Geotechnics; Design; Dynamic stability; Vibro Replacement; Gravel/Stone columns*

High-Speed Rail (HSR) is considered a key element of transport infrastructure, having been developed worldwide for many years, while in Poland, this engineering challenge is only just beginning. HSR includes lines allowing speeds of at least 250 km/h, as well as lines built to high-speed standards enabling speeds of 200 km/h. One of the crucial elements in ensuring train traffic safety is the proper preparation of the soil substrate, including specialised geotechnical works.

Currently, HSR is designed based on the technical standards of the Central Communication Port (CPK) [1], applicable to speeds equal to or lower than 350 km/h. These standards must be applied in geotechnical calculations for earth structures, such as verifying the load-bearing capacity of the soil and the stability of slopes and embankments (ultimate limit states), along with an analysis of displacements and deformations (serviceability limit states). The design process itself follows Eurocode standards: PN-EN 1990, PN-EN 1991, and PN-EN 1997, with the basic service life of railway earthworks set at 100 years.

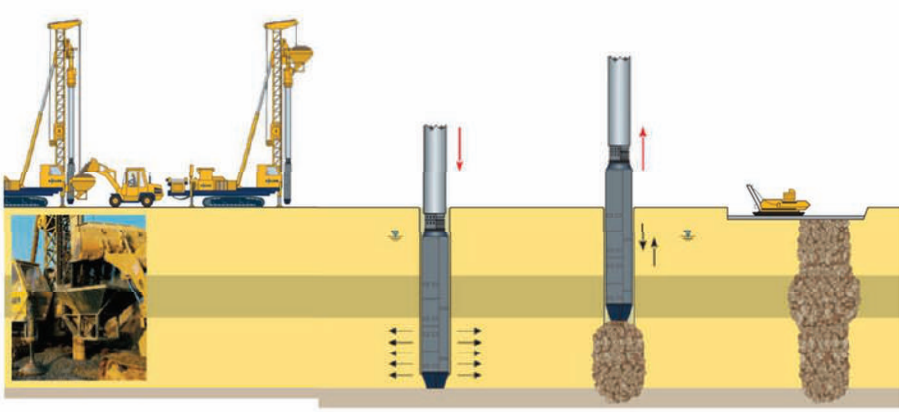
The impact of railway rolling stock in terms of design load is defined in the same manner as for conventional railways. The traffic load according to the LM71 model, in line with PN-EN 1991, is a uniformly distributed load of 3.0 m in width and 6.4 m in length, positioned 0.7 m below the rail head, with a value of 63 kPa. This is the characteristic vertical load for mainline and first-class railways, for which the dynamic factor no longer applies.

Verification of soil bearing capacity, slope stability, and analysis of displacements and deformations is conducted in the same manner as for conventional railways. However, the threshold values for displacements used to verify serviceability limit states have been defined differently. The fundamental requirement for the trackbed is to ensure its acceptable settlement throughout its operational period, starting from the moment the track structure is completed. Accordingly, permissible post-construction settlement values for HSR trackbeds have been specified.

Settlement or unevenness of the trackbed during its operation may necessitate adjustments to track positioning, potentially compromising stability. In the case of ballastless tracks, such settlements may prevent vertical adjustments to track positioning or even cause structural damage to the track system.

A completely new issue in HSR is dynamic stability. Under cyclic loading caused by railway traffic, dynamic effects occur in the soil substrate. Depending on soil conditions, groundwater level, or underground obstacles, multidirectional wave propagation occurs in the soil, with interference and reflections. Vibrations of the track system itself also take place, causing its movement and deformation. The waves propagating in the soil substrate are divided into longitudinal body waves (P-waves – compressional) and transverse body waves (S-waves – shear) as well as surface Rayleigh waves (R-waves). Soil vibrations caused by trains travelling at speeds above 150-160 km/h can lead to a deterioration of its properties, excessive settlement, and even liquefaction. Soils sensitive to vibration include easily displaceable sands with a grain uniformity coefficient below 2.0 and a relative density ID < 0.5, cohesive soils with a liquidity index IL > 0.4, and organic soils of various types and origins. Soil stability is adversely affected by groundwater saturation, while it is improved by a cover of stronger soil. The dynamic stability of sensitive layers is at risk when train speeds approach the velocity at which surface R-waves propagate (the so-called critical velocity). To prevent adverse effects, it is recommended that the ratio of train speed to wave propagation velocity does not exceed 0.65-0.70. This condition can be met through various geotechnical solutions – from soil improvement through its reinforcement to foundation solutions using piles.

Among the geotechnical technologies that improve the load-bearing capacity of the soil substrate, the stability of slopes and embankments, including dynamic stability,



1. Diagram of gravel column installation [4]

as well as reducing displacements and deformations, vibro-replacement can be considered the fundamental and most reliable method. The execution of sand, sand-gravel, or gravel columns using this technology allows for the appropriate reinforcement of the soil substrate to meet the required design parameters. This reinforcement is achieved in two ways: on one hand, a coarse-grained, non-cohesive material is introduced into the soil substrate, which is vibrationally compacted during installation, and on the other, the existing soil is spatially strengthened through lateral displacement and the aforementioned vibrations.

The vibro-replacement technique involves the formation of aggregate columns in weak soil using a deep vibrator with internal material feeding. In the first phase of column installation, the vibrator is filled with aggregate and penetrates the substrate under the influence of vibration and the pressure of the base machine (Fig. **1**). Upon reaching the depth specified in the design or the required penetration resistance, an expanded gravel base is formed in the load-bearing soil. In the second phase, the gravel column shaft is constructed within the reinforced soil layers. For this purpose, coarse-grained aggregate is poured into the vibrator from above through a closed sluice.

As the vibrator is gradually lifted, the aggregate flows out from beneath the vibrator's tip with the assistance of compressed air, filling the space previously occupied by the vibrator. Subsequently, lowering the vibrator again causes the aggregate to be pushed sideways, increasing the effective diameter of the column. This reciprocating movement of the vibrator is continued along the entire length of the gravel column. During the formation of the shaft, the column diameter adjusts to the lateral deformability of the soil, ranging from approximately 0.5 m to even 0.8 m, meaning that in weaker soils, the diameter is larger, while in more resilient soils, it is smaller. Due to the shape of the vibrator, the column assumes an oval cross-section. An additional effect accompanying the formation of the gravel column shaft is the improvement of the mechanical properties of the surrounding soil. The native soil undergoes further strengthening due to compaction (in the case of granular soils) or accelerated consolidation (in the case of water-saturated cohesive soils). The required substrate stiffness, meeting the serviceability limit state (SLS) requirements, is achieved by employing an appropriately designed grid of columns with a specified diameter and length. A characteristic feature of soil reinforcement using vibro-replacement columns, which are treated as elements of spatial soil improvement, is their ability to significantly reduce settlement, particularly in weak soils. The adopted soil reinforcement method is volumetric, leading to a relative enhancement of the strength parameters of the soil between the columns. The construction of a gravel column head ensures the flexible support of the railway embankment, eliminating the risk of a punching effect. An important aspect of this technology is the ability to adjust the length of each column to actual soil conditions at a given point, thanks to the continuous measurement of the vibrator's penetration resistance in the substrate.

The equipment used in vibro-replacement technology allows for flexible delivery of various types of materials forming the column within the soil. These materials may include aggregate, a cement-gravel mixture, or semi-dry concrete. Given the lack of technological limitations, in cases where organic soil layers exceed the diameter of the column, cementation of part of the gravel column shaft should always be considered.

Achieving the intended ground reinforcement parameters outlined in the design phase is not feasible without the use of appropriate equipment that ensures control and monitoring of the technological process at every stage. This equipment features advanced structural solutions as well as a quality control system and production parameter recording [2]. The equipment must provide sufficient downward force to facilitate the vibrator's penetration through more compacted soil layers with the assistance of compressed air, enable the installation of columns of a length determined by the requirement to reach the load-bearing layer while continuously measuring the penetration resistance of the vibrator in the substrate, allow the introduction of aggregate to the required depth and the formation of an enlarged gravel base in load-bearing soil, and ensure full control over the amount of embedded aggregate and the compaction of the column shaft during its formation along its entire length (Fig. **2** to Fig. **5**). Only such technical solutions allow for the utilisation of one of the fundamental characteristics of gravel columns—their self-regulation capability, meaning their ability to adapt to the lateral flexibility of the soil and the applied loads. These solutions also help minimise friction on the vibrator casing and extension tubes, thereby achieving high operational efficiency without compromising product quality.

The GPS positioning system installed on the machines (Fig. **6**) enables precise determination of reinforcement point locations on the working platform, replacing traditional geodetic measurements and accelerating the production process, particularly for large-scale projects.

Effective compaction requires the use of an appropriate type of vibrator, one of the key components of the entire system (Fig. **7**). Vibrators differ in power, frequency, vibration amplitude, and centrifugal force, and the selection of these parameters according to soil conditions is of fundamental importance. It should be emphasised that the vibrator, as a source of vibrations, must be mounted at the lower part of the working tool so that energy is generated precisely where it is needed for compaction. This eliminates long transmission paths with significant damping losses, as is the case with top-mounted vibrators. Such solutions require a tube with a diameter corresponding to that of the column, which in turn necessitates the use of a lar-

Tab. 1. *Acceptable post-construction settlement values for HSR trackbed*

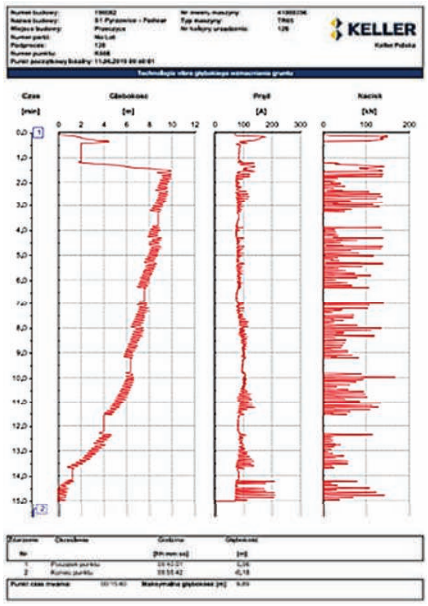
Type of displacement	Ballastless track	Ballasted track
Maximum post-construction settlement S_R	15 mm	50 mm
Maximum inclination angle due to settlement differences	1/1,000	1/1,000 (*)
Predicted post-construction settlement difference between embankment and structure support	20 mm over 20 m distance	20 mm over 20 m distance (*)

(*) The stated value applies to the trackbed regulation/repair period, which is 5 years

2. *View of the quality control and data recording system with the production control panel in the operator's cabin [4]*

3. *Quality control and data recording system [4]*

4. *Machine for gravel column installation [4]*



5. *Record of a completed column [4]*

6. *Machine equipped with a GPS positioning system [4]*

ger carrier machine, generating the need for a more stable working platform, increased energy consumption, and often, due to the lack of pressing force, additional pre-drilling equipment, significantly increasing the implementation costs. Top-mounted vibrators have significant depth limitations, allowing for the execution of 'columns' only a few metres long, without the ability to control the construction process or engage the surrounding soil in cooperation, particularly in weak soils. Among other reasons, the PN-EN 14731:2005 standard does not permit the vibro-replacement method using top-mounted vibrators. Both the main machines and vibrators are designed and manufactured by KGS Keller Geräte & Service GmbH, a subsidiary of the Keller Group, whose factory is located in Renchen, Germany.

Sand, sand-gravel, and gravel columns using the vibro-replacement technology have been implemented in Poland for over 20 years across all sectors of construction. When discussing examples of vibro-replacement column applications for conventional railway lines in Poland, it is worth mentioning the soil reinforcement on line 227/249 and at Gdańsk Zaspa Towarowa station, as well as on line 722 as part of the Improvement of Railway Infrastructure Access to the Port of Gdańsk project, which Keller completed in 2020. Based on static analyses conducted using the widely applied Priebe method, the project adopted gravel columns at nominal spacings of 1.8 m × 1.8 m (Fig. **8**) and, within the transition zones, at 2.5 m × 2.5 m. The applied transverse spacing and staggered layout of the vibro-replacement columns ensure uniform reinforcement of the track bed, regardless of the geometric position of the track. To minimise settlement differences and provide a gradual change in substrate stiffness between the existing, non-reinforced soil and the reinforced section, transition zones were designed in each case. The purpose of the transition zone is to equalise settlement at the junction of the reinforced and non-reinforced areas, preventing the so-called 'step effects.' The project specified that the base of the vibro-replacement columns should be embedded at least 1.0 m into load-bearing soil; however, the designed column lengths are always subject to final verification on-site, based on the observed and recorded soil resistance during execution. Following the completion of works (Fig. **9**), from the final acceptance (marking the beginning of the warranty period), the track settlement range should not exceed the permissible values of 4 mm per year over 30 m or 10 mm per year over 200 m, in accordance with §7 of the Id-3 instruction and the total allowable settlements specified in the construction design: sdop ≤

1.0 cm.

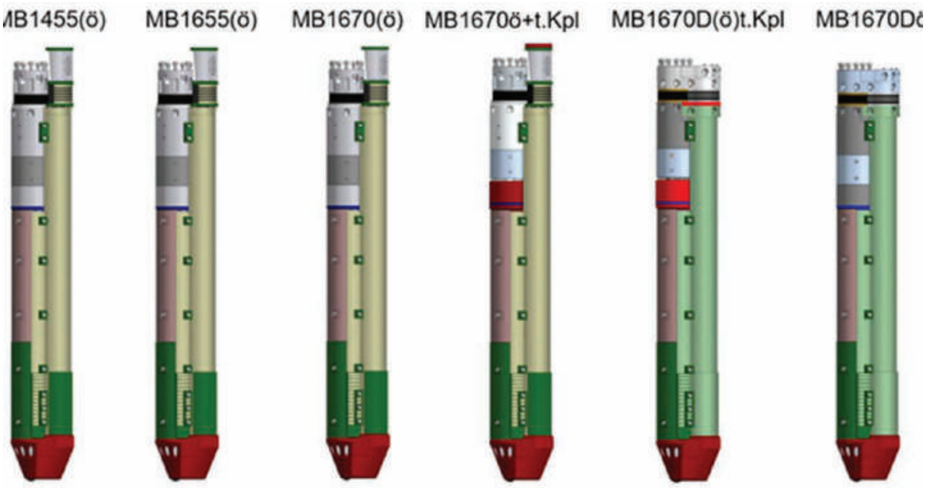
For high-speed rail projects in Europe, an exemplary case is the work completed by Keller Grundbau GmbH in Germany for Deutsche Bahn AG. As part of the expansion of the high-speed rail network (ICE, Intercity Express) on the section from Hanover to Berlin, in the area of the bridge over the Elbe River in Schoenhausen, it was necessary to reinforce an existing embankment built 150 years ago, adapting it for train speeds of up to 250 km/h. In the first phase of construction, the existing embankment was widened, creating a working platform (PR1, as shown in Fig. **10**) for the installation of gravel columns approximately 4.0 m in length. Subsequently, a new embankment was raised by approximately 4.0 m, forming another working platform (PR2) for the proper reinforcement of the existing embankment. The gravel columns, arranged in an orthogonal grid of 1.85 × 2.15 m and approximately 8 m in length, ensured compliance with the load-bearing and serviceability limit state requirements for the designed railway line.

In 2022, Keller Foundazioni completed several sections of soil reinforcement using vibro-replacement technology for high-speed rail (Eurostar Italia), installing gravel columns beneath embankments for the new Milan–Venice railway line in Italy. Part of the route passes through the Lake Garda region, where weak lake-origin soils were reinforced as part of the project.

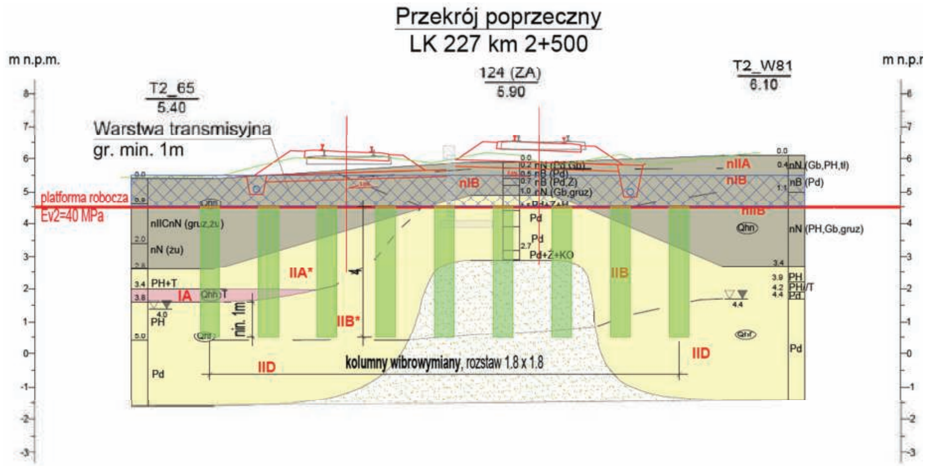
Due to many years of global experience in the implementation of gravel columns for soil reinforcement, numerous technical publications contain scientific articles describing the positive impact of this reinforcement on dynamic stability. Study [5] found, among other things, an increase in critical velocity ranging from several to dozens of percent in weak-bearing soils after reinforcement with gravel columns. Study [6] analysed various scenarios of a single or two trains moving at different speeds and in different directions, both on soil reinforced with gravel columns and without such reinforcement. In the reinforced scenario, a reduction of up to 50% in vertical track deformations was recorded when a single train passed at 300 km/h.

Environmental considerations are now a key aspect of construction projects. Soil reinforcement technologies that do not use concrete or cement generally result in significantly lower CO_2 emissions. This is confirmed by carbon footprint calculations carried out using a calculator developed with the participation of the European Federation of Foundation Contractors (EFFC), comparing construction projects identical in technical terms but executed using different technologies and materials [3]. Gravel column technology proves particularly advantageous in this regard, as it relies on natural materials (gravel, sand), reducing emissions by up to 80% compared to solutions using steel, concrete, and cement (such as piles and cement or reinforced concrete columns).

The development of High-Speed Rail is a well-justified direction for transport infrastructure advancement in our country. While we must address new technical challenges, we also benefit from the knowledge and experience gained from similar projects in other countries. In the field of geotechnical works, various solutions are available—ran-

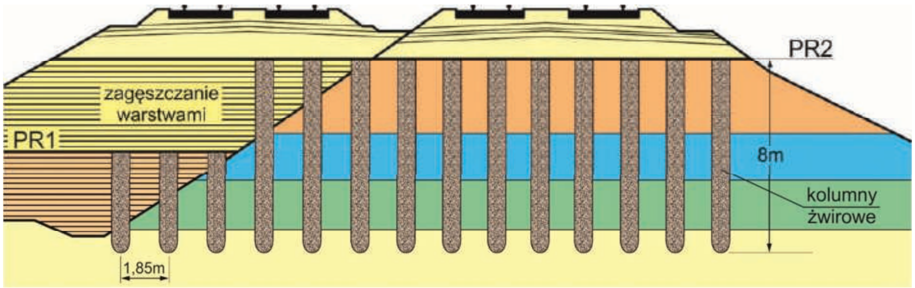


7. Types of vibrators for vibro-replacement [4]

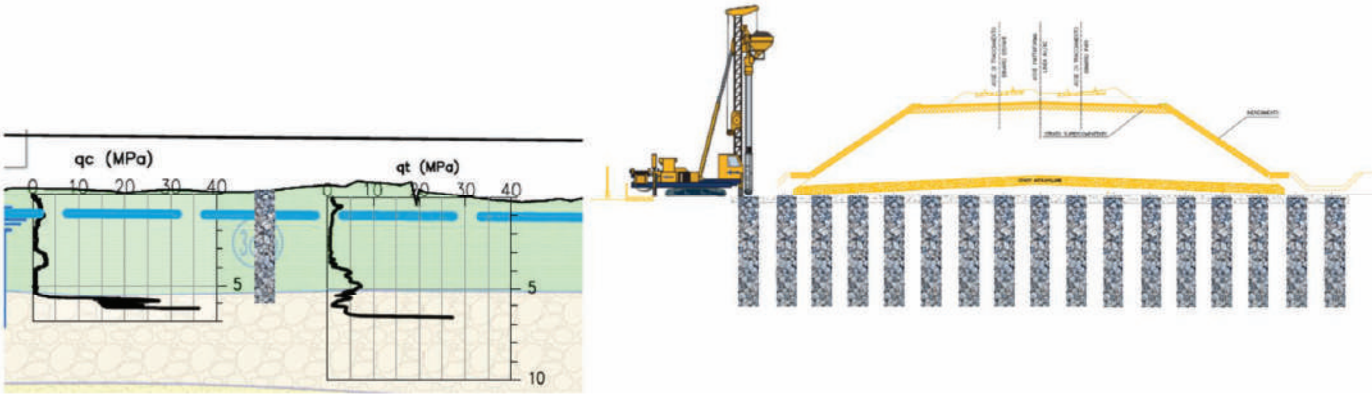


8. Typical cross-section of soil reinforcement using vibro-replacement [4]

9. Implementation of vibro-replacement columns [4] ging from soil reinforcement to piling—that ensure compliance with the required conditions for track beds. However, vibro-replacement technology appears to be one of the leading methods, as it is proven and virtually fail-safe due to the full control of production parameters. It has been used in High-Speed Rail projects worldwide for many years, providing a safe and environmentally friendly foundation. ◀

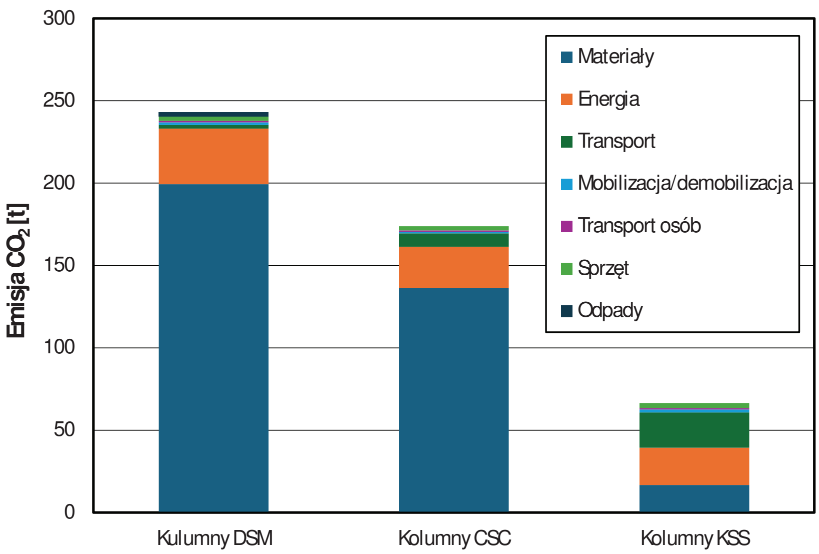


***10**. Typical cross-section of soil reinforcement using vibro-replacement [4]*



***11**. Example scope of soil reinforcement using vibro-replacement [4]*

***12**. Implementation of vibro-replacement columns [4]*



***13**. Comparison of CO_2 emission calculations for CSC, DSM, and gravel columns for reinforcement works valued at approximately PLN 500,000, calculated using the EFFC calculator*

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Integration of high-speed rail baggage traffic in relation to the Central Communication Port

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Abstract: In June 2018, IATA (International Air Transport Association) voted to develop a standard for the use of RFID for baggage tracking within one year, with the aim of rolling out the technology worldwide by 2021.
RFID technology was selected over other tracking solutions based on its reliability, maturity, widespread availability and cost of implementing the technology.
The technology enables tracking of baggage from the place of check-in, e.g. the train where the traveller boards, until the moment of collection at the destination airport on the mobile phone and by airport services.
Airlines are required to share information about baggage loaded onto an aircraft from the departure airport to the destination airport.

Keywords: *RFID; IATA; Baggage; High Speed Rail; CPK; Mishandled Bsgs*

According to 2024 SITA Baggage IT Insights report number of mishandled bags is dropping from 7.6 to 6.9 per 1,000 passengers in 2023. Taking into account the increase in the number of passengers to 5.2-5.4 billion in 2024, this gives a total number of around 40 million units of mishandled bags in 2024. In 2023, delayed bags accounted for 77% of all mishandled bags. At the same time, the number of lost and stolen bags decreased slightly to 5% in 2023. Meanwhile, the number of damaged and tampered bags increased to 18%. The majority of mishandled bags are still transfer bags. In the past, we saw an increase in the number of long-haul flights, which fueled this trend. This continued into 2023, when more passengers arrived, leading to even more long-haul flights. As a result, the number of delayed bags at transfer points increased to 46% of all mishandled bags, an increase of 4 percentage points compared to 2022. At the same time, the number of mishandled incidents due to lack of loading decreased slightly by 1%, accounting for 16% of cases in 2023. Ticket errors, misplaced bags, security issues and other miscellaneous factors combined to account for 14% of mishandled bags. Mishandling attributed to airport operations, customs clearance, weather or space weight restrictions remained stable at 8%. Mishandling of arrivals remained steady at 4%, while delayed bags due to airport loading errors remained at 8%, reflecting 2022 data.

Airlines and airports continue to automate baggage processes. At the moment 85% of airports already introduced self-service bag drop technologies. Baggage mishandling rate is dropping, in part due to messaging improvements. This was followed by the introduction of IATA Resolution 753 for the tracking of luggage, which became effective in June 2018. IATA Recommended Practice (RP) 1740c contains RFID specifications for interline baggage that were revised in 2018 to reflect the latest developments in RFID technology and to include a set of tests to ensure that global performance standards are met.

The above data clearly indicate that the issue of baggage logistics in the aviation sector is of great importance and still constitutes a serious challenge, which, according to IATA recommendations, can and should be supported by RFID technology.

In addition to baggage handling issues, the aviation sector is also facing increasing climate protection requirements. According to limitation in temperature rise by 2050 in the EU, greenhouse gas emissions in the transport sector must be lowered by 70% compared with 2008. Given the assumption that mobility will continue to increase and, consequently, traffic volumes will increase, greenhouse gas reductions can only be achieved through increased use of environmentally and resource-saving modes of transport. For this purpose, the European Commission has set ten objectives for the transport sector in the document entitled " Roadmap to a Single European Transport Area - Towards a Competitively Oriented and Resource-Conserving Transport System ". One of these objectives targets long-haul passenger traffic and proposes the following measures:

- Completion of a European high-speed railway network by 2050
- Tripling the length of the existing network by 2030 and maintenance of a dense rail network in all member states
- By 2050 the majority of passenger transport over middle distances should be allotted to the railway.

To best meet these goals, one feasible approach is to switch from air to rail for short haul flights, which serves as a feeder for medium- and long-haul flights. There are many opportunities for cooperation between the aviation and rail sectors in this regard. Currently, about 130 of all airports in the world are connected by rail, and more rail connections are planned. Initially, rail connections played only a limited role, mainly providing local transport and primarily connecting city centers and surrounding areas with airports. It is only in the last few years that concepts of connecting city centers with airports have been implemented, enabling fast connections (e.g. Heathrow Express in London) and in some cases also connections providing service functions such as check-in or baggage drop-off (e.g. CAT in Vienna).

The services "Check-in at the Train Station" and "Fly Rail Baggage" are offered in cooperation between SBB and the airports in Zurich, Bern and Geneva. Passengers can check in their flight baggage at 56 railway stations in Switzerland ("Check-in at the Train Station") and receive their boarding pass at the same time. The baggage is then checked into the aircraft3.

The construction of the CPK in Poland opens up the possibility of introducing similar services at train stations in Warsaw, Łódź, Kraków, Katowice, Poznań, Gdańsk, etc., allowing high-speed rail passengers travelling to the CPK to check in their luggage and print their boarding passes themselves. Passengers can check in their luggage at the train station, which makes train travel easier, increases the amount of space for passengers and significantly speeds up the process of boarding and disembarking from the train. As experience from Japan shows, accelerating passenger movement is of great importance for the punctuality of high-speed trains. The introduction of such a service carries additional risks, as another baggage reloading point appears in the baggage logistics process, which may cause loss or delays. Statistical data clearly indicate that in the aviation industry, it is transferred baggage that is most often the cause of delays. Baggage checked in at train stations must therefore be marked with RFID tags in accordance with IATA recommendations so that it can be tracked throughout the logistics process. RFID readers installed at train stations and in train luggage compartments will allow tracking of the baggage handling process at train stations, including the process of sorting and loading baggage onto individual trains. Additionally, in selected places by the railway tracks, it is possible to install RFID gates identifying baggage wagons and enabling tracking of the transport process itself. Luggage marked with RFID technology can be transferred directly to the luggage sorting room after being delivered to CPK. This solution will allow passengers to check where their luggage is using a simple mobile application on their phone. Whether it is travelling with them by train, or another train, how far it is from the airport, whether it is already at the airport and, most importantly, whether it is already on the plane. Thanks to the use of the international marking standard recommended by IATA (including massaging), even after landing at another airport, the passenger can check what is happening with their luggage. Whether it has already been unloaded, whether it is on the "carousel" and in the case of a transfer, whether it is loaded onto a new plane. HADATAP from Warsaw successfully implemented an RFID solution for the identification and tracking of railway rolling stock at Orlen. As part of the project, 150 dedicated RFID rail gates were installed throughout Poland (**1**).

The gates used in the project enable the identification of several thousand Orlen fuel tankers, which have been marked with RFID tags (**2**) resistant to environmental conditions (two for each tanker).

A similar solution can be used to mark high-speed railways between railway stations and CPK. In the area of application of RFID technology for marking baggage on the domestic market, some limited implementation projects were also carried out. HADATAP successfully launched a baggage control system at the Chopin Airport in Warsaw and Rzeszów-Jesionka. In summary, taking into account the above-mentioned problems in the field of baggage logistics in air transport and the growing requirements related to environmental protection, the implementation of intermodal solutions allowing for baggage drop-off at railway stations seems to be the only possible path of action. Unfortunately, expanding the number of baggage drop-off points outside the airport and adding complex logistics processes at railway stations can cause problems that cause delays. This is clearly visible in statistical data indicating baggage transfer as a key source of operational problems in the industry. Based on IATA recommendations and experience gained, it is possible to effectively implement the new model, but only when using an identification technique such as RFID. The use of multiple identification points, starting from the self-drop-off point, through the sorting process at the railway station, loading, transport by baggage wagon to unloading at the CPK and transfer to the airport sorting facility, will allow both railway and airport employees and passengers to monitor the logistics process in real time and dynamically respond to any irregularities. Currently, in Poland, HADATAP has successfully implemented an RFID solution that can be the basis for the implementation of the project presented in this publication.◀

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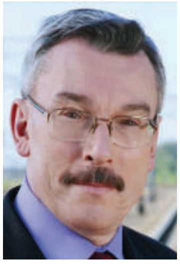
1. RFID rail gates

2. RFID tag marking

The CPK project as an opportunity for the development of the Łódź region



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Abstract: In recent months, the CPK acronym has probably been the most frequently used acronym in public space. Debates, and often very emotional disputes, have focused on the issue of whether the central airport and the associated railway system are needed at all, whether it is – or is not – oversized, etc. On the other hand, the impact of such a large investment project on the economic and social development of the regions that will be within the range of CPK's impact has been less emotional. The Łódź province, after the implementation of infrastructure investments currently carried out by PKP Polish Railway Lines S.A., as well as those prepared by Central Communication Port Sp. z o.o., may be one of the greatest beneficiaries of this epochal project.

Keywords: *CPK; Lodz Region*

At the centre, yet on the sidelines

The first railway line in the Kingdom of Poland, the Warsaw-Vienna Railway, built between 1845 and 1848, bypassed Łódź—a rapidly developing centre of the textile industry—on its eastern side. Transporting goods via the Piotrków route to Rokiciny, approximately 30 km away, was cumbersome and time-consuming. Consequently, at the initiative of a group of Łódź industrialists, a branch line was built from the newly established Koluszki station to a dead-end station in the centre of Łódź, named Łódź Fabryczna—the so-called Łódź Factory Railway, which opened in 1866. The name of the Łódź station fully reflected its purpose, which was primarily to serve industrial plants. Passenger transport was a secondary function, which initially resulted in a limited number of connections and frequent complaints from travellers about the conditions at stations and in railway carriages.

Both lines were constructed with a standard gauge of 1,435 mm, as the Warsaw-Vienna Railway was originally designed to facilitate the export of goods to the southern parts of the Kingdom, where it connected with the Prussian and Austro-Hungarian railway networks, which had the same track gauge.

More than a decade later, in the 1880s, another major railway line, the Ivangorod (Dęblin)-Dąbrowa Railway, was constructed in the Kingdom of Poland, this time with a track gauge of 1,524 mm, in accordance with the regulations then in force in Tsarist Russia. A branch of this line reached Słotwiny near Koluszki in 1885, and following the construction of a connecting line in Koluszki, the railway lines of three different companies converged at a shared station.

Łódź industrialists quickly recognised the potential cost savings in transport that could be achieved by shipping goods to Tsarist Russia via a broad-gauge railway, eliminating the need for transhipment at junctions where different track gauges met. Even while the Dęblin-Dąbrowa Railway was still under construction, they initiated the development of a line that would bring broad-gauge tracks into Łódź. This railway, named the Orbital Railway, was opened in 1903. From Słotwiny, it passed over the tracks of the Warsaw-Vienna Railway and, beyond the present-day locality of Żakowice, approached the tracks of the Łódź Factory Railway, running parallel to it until reaching Łódź Widzew station. From there, the Orbital Railway skirted the outskirts of the city, passing through Chojny and Karolew to Łódź Kaliska station, where it connected with the broad-gauge Warsaw-Kalisz Railway, then under construction.

However, the primary purpose of the Orbital Railway was not, as one might assume, to facilitate transit traffic through Łódź. Instead, it was mainly designed to serve the dense network of sidings that surrounded the city's industrial plants.

The section of the Orbital Railway between Łódź Widzew and Łódź Kaliska was equipped with tracks of two different gauges: on the city-centre side, a standard-gauge of 1,435 mm track was laid, while on the outer side of the Orbital Railway, a broad-gauge of 1,524 mm track was installed. This configuration ensured the versatility of freight dispatching, avoiding the need for transhipment. This explains why the Łódź Chojny station, as well as the now-unused Łódź Karolew station, were located between the two groups of tracks—a feature that continues to puzzle some residents of Łódź today.

The priorities of Łódź's industrialists, focused on freight transport, ultimately shaped the Łódź Railway Junction (ŁWK), as illustrated in Figure **1**.

The first visible effect of Poland regaining independence in 1918 on the Łódź Railway Junction (ŁWK) was the gradual standardisation of all railway track gauges to 1,435 mm. Both city authorities and railway decision-makers were well aware of the dysfunctional layout of the ŁWK left behind after the Russian partition. Among the notable plans was that of engineer Edward Szenfeld, developed in 1919, which not only proposed the construction of a complete orbital railway around Łódź but also envisaged new, shorter routes from Łódź to Skierniewice, Piotrków Trybunalski, and Poznań. Notably, the terminus layout of Łódź Fabryczna station was retained. In the early years of the Łódź Factory Railway, there had been plans to extend the line westwards—creating something akin to Berlin's S-Bahn—but the city's rapid urban expansion made such plans unfeasible.

However, the young Polish state lacked the funds to implement these ambitious ideas. The priority was to improve coal exports from Upper Silesia, which was Poland's key export commodity. As a result, rather than executing Szenfeld's vision, the ŁWK saw the construction of new rail connections between Zgierz and Kutno, completed in 1925, and between Łódź Widzew and Zgierz, completed in 1931. These lines shortened the routes for coal trains coming from southern Poland, allowing them to bypass the city centre.

The final addition to the ŁWK expansion was the Łódź Chojny – Bedoń junction line, including the Łódź Olechów marshalling yard.

This investment was initiated by the Germans in 1943, as part of the so-called Otto Plan, and was later completed by the Polish authorities after the war. In 1978, the Łódź Olechów bypass line was opened, along with a connecting track to Łódź Widzew. Additionally, from Bedoń to Gałkówek, a separate pair of tracks for freight traffic was built, which later became part of the current Line No 25.

This final configuration of railway lines forming the Łódź Railway Junction (ŁWK) has not only survived for over 70 years—it remains in place to this day!

The authorities of the city of Łódź and railway officials were well aware of the dysfunctional layout of the Łódź Railway Junction (ŁWK). Architectural studios in Łódź began working on reconstruction plans, but in 1958 the proverbial final nail in the coffin was driven in: the Regional Directorate of State Railways in Łódź was liquidated as part of PKP's organisational changes. The Łódź Railway Junction was placed under the authority of the Central Regional Directorate of State Railways (DOKP) in Warsaw, which had enough of its own problems with the Warsaw railway hub to consider undertaking the reconstruction of the ŁWK.

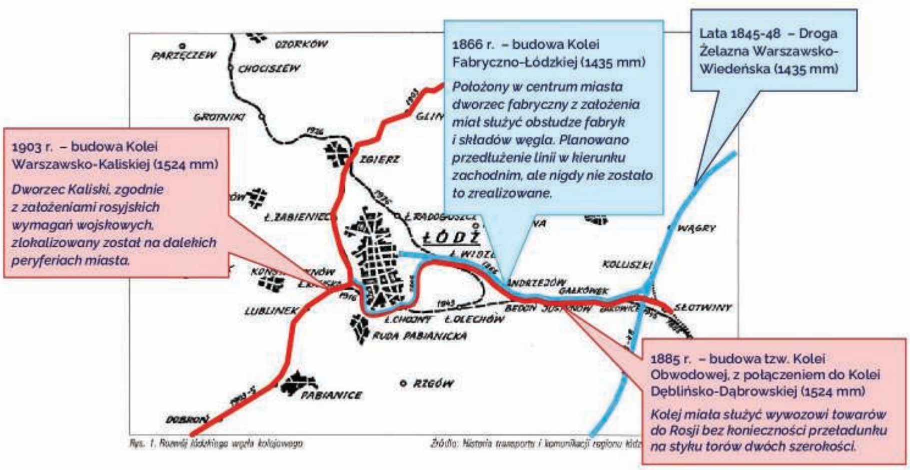
The growing demand for passenger transport in a rapidly rebuilding post-war Poland revealed how much the layout of the ŁWK hindered the smooth operation of train traffic. Long-distance trains running between the north (Tricity, Toruń, Bydgoszcz, Poznań) and the south (Katowice, Kraków) had to bypass Łódź via the orbital railway, making a 270° turn and losing significant time passing through the Łódź hub. No transit trains on this route could stop at the centrally located Fabryczna station, which in practice served only regional connections to Warsaw.

The situation was even worse for east-west traffic, such as trains from Warsaw to Wrocław. Not only did they have to bypass Łódź via the orbital railway, but they also faced the challenge of changing direction at Kaliska station. Due to the location of the station building between two groups of tracks—eastern tracks from Łódź Chojny and western tracks from Pabianice—a simple locomotive change was not possible. A train arriving from Warsaw had to be pulled forward into the northern track group of Łódź Kaliska, then the carriages had to be pushed back to the platforms on the western side, where the locomotive could finally be attached at the opposite end—a process that took at least 25 minutes. This issue was temporarily resolved in the second half of the 1980s by constructing track No 81 from the southern junction of Łódź Karolew station (later renamed Łódź Kaliska Towarowa), allowing direct entry to the western side of Łódź Kaliska station. However, even with this modification, the time loss due to the change in direction remained unavoidable.

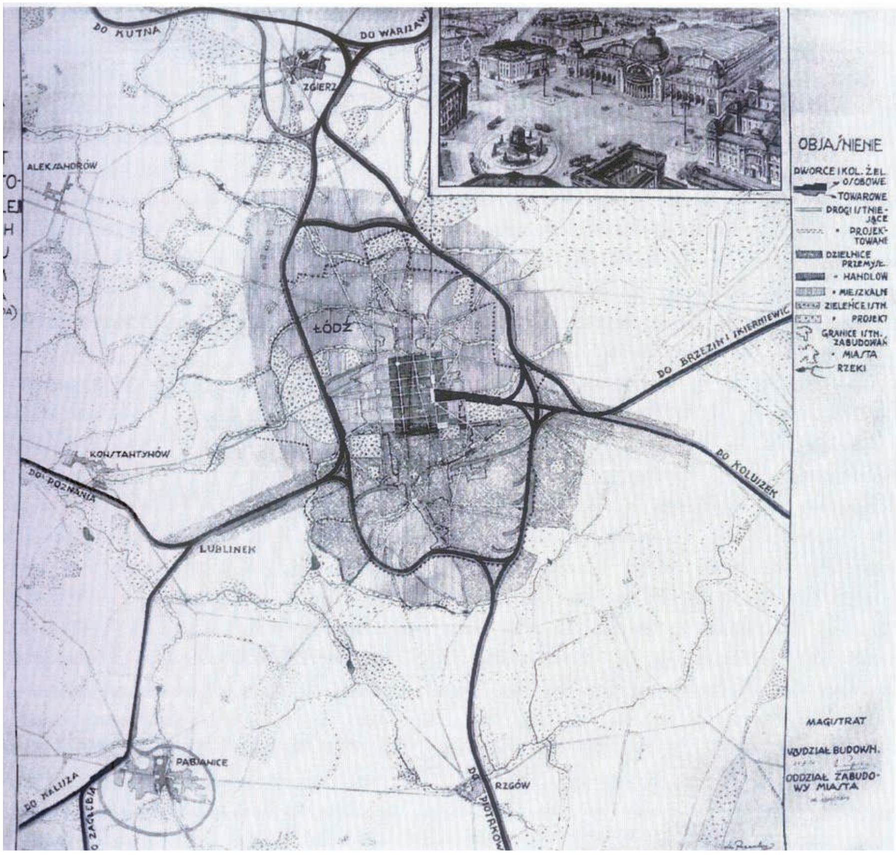
An alternative was to stop transit trains at Łódź Chojny station, bypassing Łódź Kaliska altogether. However, this meant that Łódź had yet another station handling long-distance traffic—the third one in the city. A resident of Łódź planning a journey first had to determine which station their train departed from, and in an era without online search engines, this was no easy task. On a daily basis, simply getting through to railway information services by phone was a struggle.

Changing trains in Łódź often required taking a tram or taxi to a different station, which practically eliminated the city as a transfer hub. In regional traffic, trains operated on two separate railway networks: the eastern network serving Skierniewice, Tomaszów Mazowiecki and Piotrków Trybunalski, and the western network serving Kutno, Łowicz and Sieradz. The western network did not serve the city centre, which was a major shortcoming, as the two largest cities in the region outside Łódź—Zgierz and Pabianice—were located along the western axis. As a result, rail transport did not play a significant role in regional travel within the Łódź region; it was primarily used for commuting to Łódź's industrial plants, particularly in the textile industry, until the sector collapsed following economic reforms. With the rapid development of road transport, the railway's role in regional mobility was completely marginalised.

The extended travel times for trains passing through the Łódź railway hub led timetable planners to one clear conclusion: the best solution was to bypass the ŁWK alto-



1. Layout of the Łódź Railway Junction at the beginning of the 20th century



2. Engineer Edward Szenfeld's project from 1919.
Source: Ch. Jensen, M. Jerczyński, Koleją przez Łódź, Księży Młyn Publishing, Łódź 2017

gether. Residents of Łódź travelling long distances, especially abroad, first had to travel to Koluszki or Kutno to board their intended trains. Dziennik Łódzki sarcastically remarked in one of its editions from that era: Łódź is a city that has its water in Pilica, its railway station in Koluszki, and its airport in Warsaw. The role of Koluszki as a transfer station for Łódź declined in the second half of the 1980s, as most long-distance and international trains from Warsaw to Katowice and Kraków were rerouted onto the Central Railway Main Line (CMK). As a result, Łódź residents now had to travel to Warsaw first…

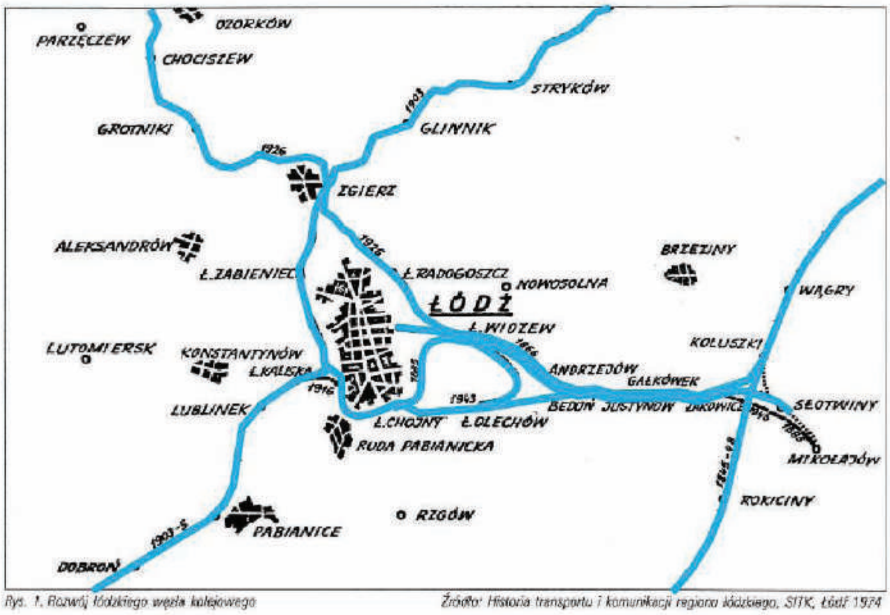
A chance to change the status quo

A rather ironic interpretation of history would suggest that Poland built its first high-speed railway line. When the Central Railway Main Line (CMK) was opened in 1977, the French government had only just approved the construction of the Paris–Lyon line, and the Italians had yet to reach the halfway point in building the Direttissima. However, the difference was that while the Italians were already running trains at 200 km/h, and the French introduced speeds of 260 km/h in 1981, the speeds of Polish trains on the CMK remained decidedly conventional. A country situated east of the Iron Curtain lacked the necessary technology to develop high-speed rolling stock, but Polish railway engineers of the time were certainly ambitious.

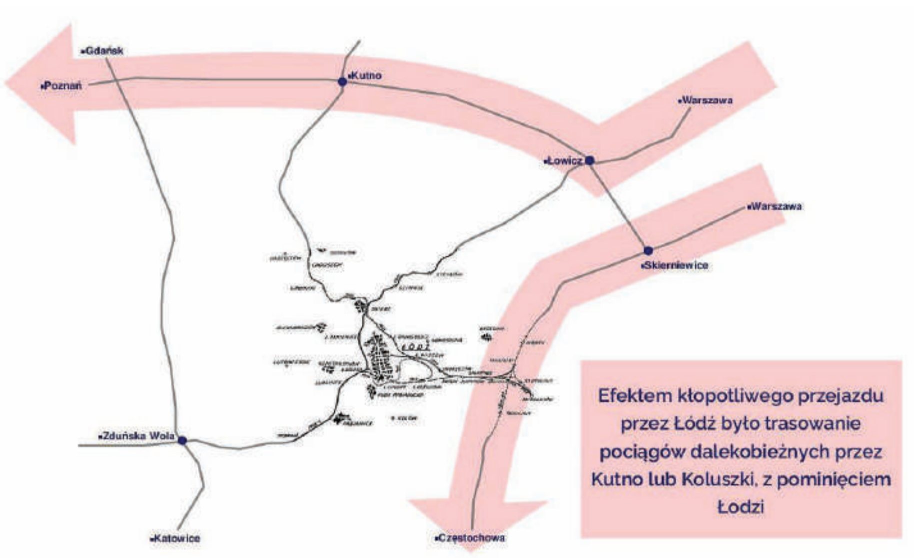
The Central Railway Main Line, which today serves as the backbone of Poland's north-south high-speed connections, was originally intended as just the first phase of a broader investment plan. However, the planned northern extension through Płock–Brodnica towards Tczew was never realised. Likewise, the proposed branch from Idzikowice to Wrocław resulted in only a single completed section between Piotrków Trybunalski and Zarzecze, which was built primarily to serve the Bełchatów coal mine and power plant.

In its 1993 strategy, the PKP General Directorate outlined plans for a major high-speed railway corridor (HSR) from Berlin through Warsaw to Moscow, running parallel to the existing E-20 railway line. Initially, the route was designed to bypass Łódź altogether (!), though it was later revised to include the city.

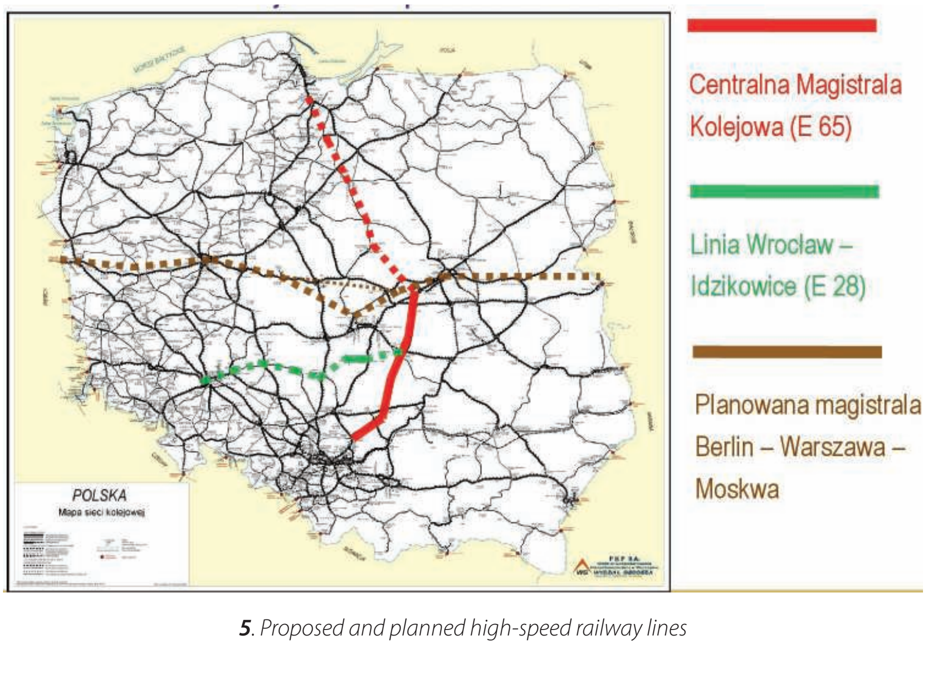
Analysing the proposed routes, which were presented together in a single diagram (see Fig. **5**), the author concluded that the planned alignments of the new HSR line and E-28 railway line should be merged, with the divergence point located as far west as possible to ensure the longest possible shared section of both lines. This led to the development of the HSR line concept, which, due to its layout, was later referred to as the 'Y-line.' The 'Y-line' concept was first presented at a conference organised by the SITK branch in Łódź in 2002 and was later discussed in an article published in the journal Technika Trans-



3. The final layout of the Łódź Railway Junction



4. The result of the dysfunctional layout of the Łódź Railway Junction



5. Proposed and planned high-speed railway lines portu Szynowego (Rail Transport Technology) in issue 10/2003.

It is worth noting that even when presenting this logical concept, the author did not dare to route the line through the city centre, instead placing Łódź on a side branch of the HSR line.

The announcement of the 'Y-line' project did not generate much immediate reaction. Several more years were needed before the topic of HSR began to take on realistic dimensions.

Poland's accession to the European Union in 2004 provided the impetus for developing national growth plans. At that time, the author, serving as a board member of PKP S.A., participated in discussions on the National Development Plan. During one of the meetings at the Ministry of Infrastructure in May 2005, the author presented the HSR "Y-line" concept to the then Minister of Infrastructure, Krzysztof Opawski, and Undersecretary of State, Marek Chałas. Both officials took up the idea and decided that PKP PLK should commission the Railway Scientific and Technical Centre (CNTK)—now the Railway Institute—to prepare a preliminary feasibility study for the Wrocław/Poznań – Łódź – Warsaw high-speed railway line. CNTK efficiently completed the study, analysing seven different route options and identifying two preferred variants (see Fig. **7**). Notably, in CNTK's analysis, the city of Łódź once again remained on the outskirts of the main HSR line.

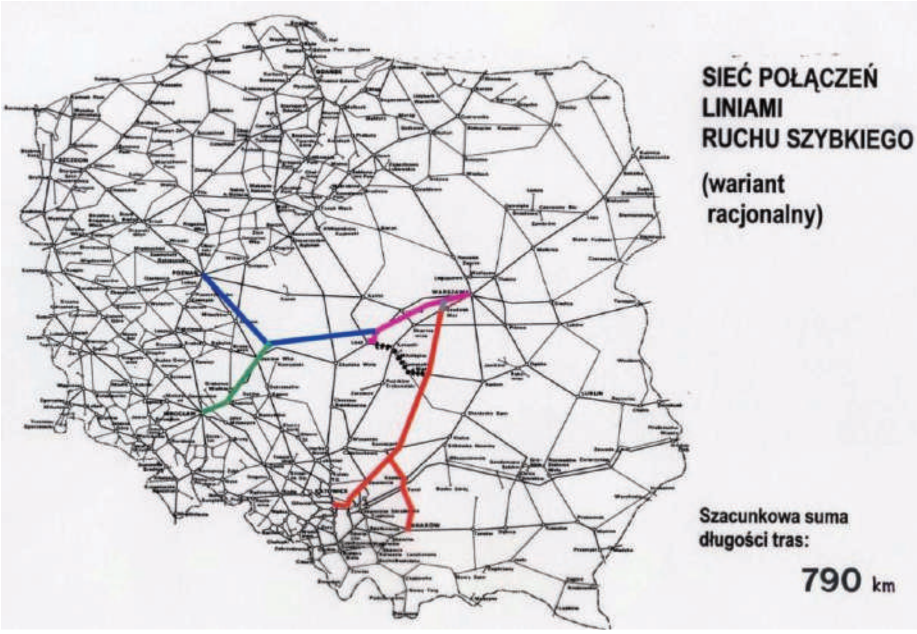
Support from the Ministry of Infrastructure for the HSR project provided motivation for extensive promotion efforts. Meetings were organised with local governments of the cities involved, and during the EurailSpeed 2005 conference in Milan, the project was presented to an international audience. In the Operational Programme 'Infrastructure and Environment' for 2007–2013, funds from the European Union were allocated for preparatory work on the HSR project.

However, the change in political leadership in autumn 2005 caused the 'Y-line' project to fade into the background for some time. But at the regional level, this period was not wasted. The Łódź community, particularly engaged following CNTK's study, intensified its efforts. Łódź, which had suffered severe transport exclusion during the communist era, was once again at risk of being left on the sidelines.

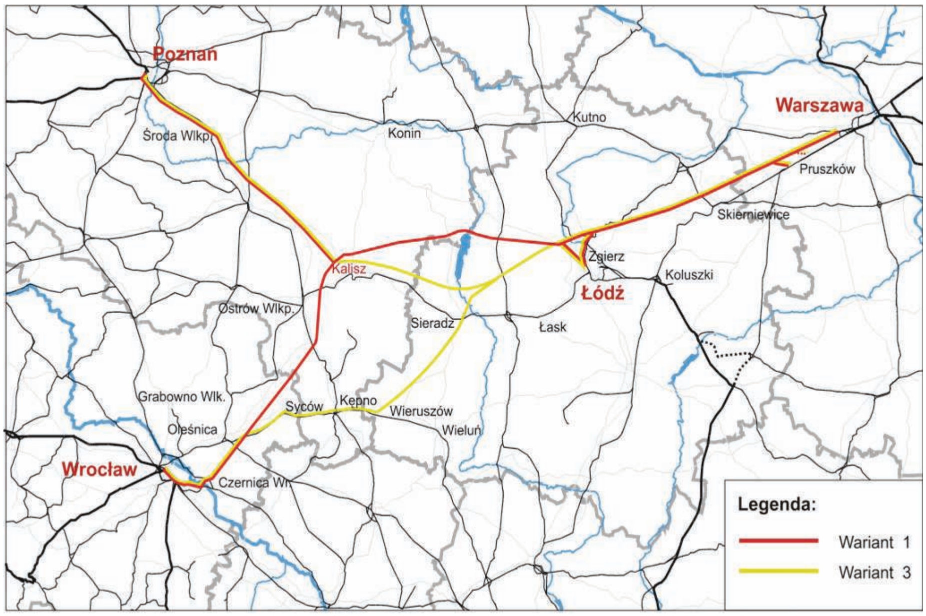
The Łódź Roads and Transport Authority, together with the Łódź branch of SITK, conducted further analyses on how to route the HSR line so that it would include a station within the city. Łódź could not afford to let history repeat itself.

Preparations and the start of reconstruction

The 2007 parliamentary election results dramatically changed the prospects for high-speed rail (HSR) development in Poland. The newly appointed Minister of Infrastructure, Cezary Grabarczyk, was a strong advocate of HSR, seeing it as a system that could completely transform both the economic foundations of passenger transport and the public perception of rail travel.



6. 'Y-line' concept – the author's original drawing from 2002



7. Preferred HSR route variants according to CNTK's study

Following the minister's strategic decision in December 2007 to develop a government strategy for HSR construction, further actions progressed rapidly in cooperation with PKP PLK S.A. and PKP S.A.. This led to the preparation of a document entitled 'Programme for the Construction and Implementation of HSR services in Poland', developed with the participation of PriceWaterhouseCoopers (now PwC). The document was approved by the Ministry of Infrastructure on 1 August 2008 and formally adopted by the Council of Ministers on 19 December 2008. With this, the green light was given to the HSR project, and the formal framework for launching preparatory and design work was established.

However, the problem of routing the line through Łódź remained unresolved. At the beginning of 2009, Minister Grabarczyk appointed the author as President of the Board of PKP Polskie Linie Kolejowe S.A. At that time, the 'Warsaw – Łódź Connection Modernisation' project was already underway. Phase I, completed between 2006 and 2008, involved the modernisation of the Skierniewice – Koluszki – Łódź Widzew section. Phase II, for which documentation was about to be prepared, included the Warsaw – Skierniewice and Łódź Widzew – Łódź Fabryczna sections. Both officials recognised that if the HSR line was to pass through Łódź, this was likely the only opportunity to integrate it into the city's infrastructure. As part of the railway modernisation project, the section from Widzew to Fabryczna, including Łódź Fabryczna station,

8. Queue at the ticket counters at Łódź Fabryczna station on 15 October 2011. Photo by the author

had to be placed underground, ensuring the possibility of extending the tunnel westward under the city centre in the future.

This concept was successfully presented to the European Commission, using arguments similar to those outlined in the chapter 'At the centre, yet on the sidelines.' Additionally, in collaboration with the Ministry of Infrastructure and the Ministry of Regional Development, funds were secured for the modernisation of the Łódź Widzew – Łódź Fabryczna section, which substantially increased the project's cost. However, when the PKP PLK Board signed a contract with IDOM Ingeniería y Sistemas on 16 September 2010 for a detailed feasibility study of the HSR line, there was no longer any doubt that the route would pass through Łódź Fabryczna station.

15 October 2011 marked the final day of operation for Łódź Fabryczna station in its original form. Large crowds of Łódź residents gathered at the station, eager to take the last train journey operated by Przewozy Regionalne to Łódź Widzew, and then return on the final PKP Intercity train from Warsaw East to Łódź Fabryczna. Inside the ticket hall, long queues stretched all the way onto the platform, as passengers wished to purchase a ticket dated for the station's final day of operation—even though both train operators had allowed free travel for this last journey. The demand was so high that Przewozy Regionalne had to operate the final train to Koluszki with two trainsets, while PKP PLK made quick operational adjustments to accommodate both trains at Łódź Widzew on platform 2. The fragile footbridge connecting platforms 1 and 2 could barely handle such a large number of transferring passengers...

The consortium led by Torpol S.A. from Poznań quickly began construction work, which soon had a positive impact on the future of the project. However, when the next Minister of Infrastructure, Sławomir Nowak, announced that high-speed rail (HSR) would not be built, the necessity of constructing an underground station in Łódź was also questioned. Fortunately, the project—crucial for Łódź—was not halted.

The underground Łódź Fabryczna station officially opened on 11 December 2016, immediately sparking mixed reactions. Some admired its spacious design, arguing that, at last, something had been built with long-term development in mind. Others criticised it as an empty, oversized structure. However, one fact remained undeniable: a key foothold for the future HSR line through Łódź had been established, with a dedicated pair of tracks for the line already in place from Łódź Niciarniana.

During this period, significant changes were also taking place in Łódź's urban and regional transport network. On the initiative of Marshal of the Łódź Voivodeship, Witold Stępień, the Łódź Metropolitan Railway (Łódzka Kolej Aglomeracyjna, ŁKA) was established in 2010 as a regional government-owned railway operator. In its initial phase, the company focused on preparatory tasks, such as rolling stock procurement tenders and the construction of a maintenance facility. Simultaneously, railway infrastructure was being modernised, not only with PKP PLK's funds but also with EU funding under the Regional Operational Programme of the Łódź Voivodeship, including the Łowicz Przedmieście – Zgierz and Łódź Widzew – Zgierz railway lines. Additionally, new stations were built or relocated to better align rail services with passenger demand.

When ŁKA began operations in 2014, it quickly became evident that a well-planned timetable and modern, comfortable trains encouraged passengers to return to rail travel—even on routes that had been considered for closure due to declining demand in previous years, such as Łódź – Łowicz.

A new phenomenon emerged in Łódź's transport system: for the first time in the city's history, passengers began using local trains for travel within the city limits, treating rail transport as an integral part of the urban public transport system. This was facilitated by full fare integration and the progressive development of intermodal transfer hubs.

In August 2019, a new groundbreaking railway investment was launched—one that would significantly improve rail connectivity in Łódź and the wider region. Commissioned by PKP PLK, this project involves the construction of the so-called 'conventional tunnel,' which in reality consists of five tunnels: one two-track tunnel and four single-track tunnels. These will enable direct rail connections between Łódź Kaliska – Łódź Fabryczna and Łódź Żabieniec – Łódź Fabryczna. Once completed, Łódź Fabryczna station will become the central hub of the region's railway network, allowing long-distance trains to pass through without the need for detours or direction changes. The shortened travel routes under the city centre and the construction of new underground stations will enable Łódzka Kolej Aglomeracyjna to provide efficient urban and suburban rail services, similar to systems like RER in Paris.

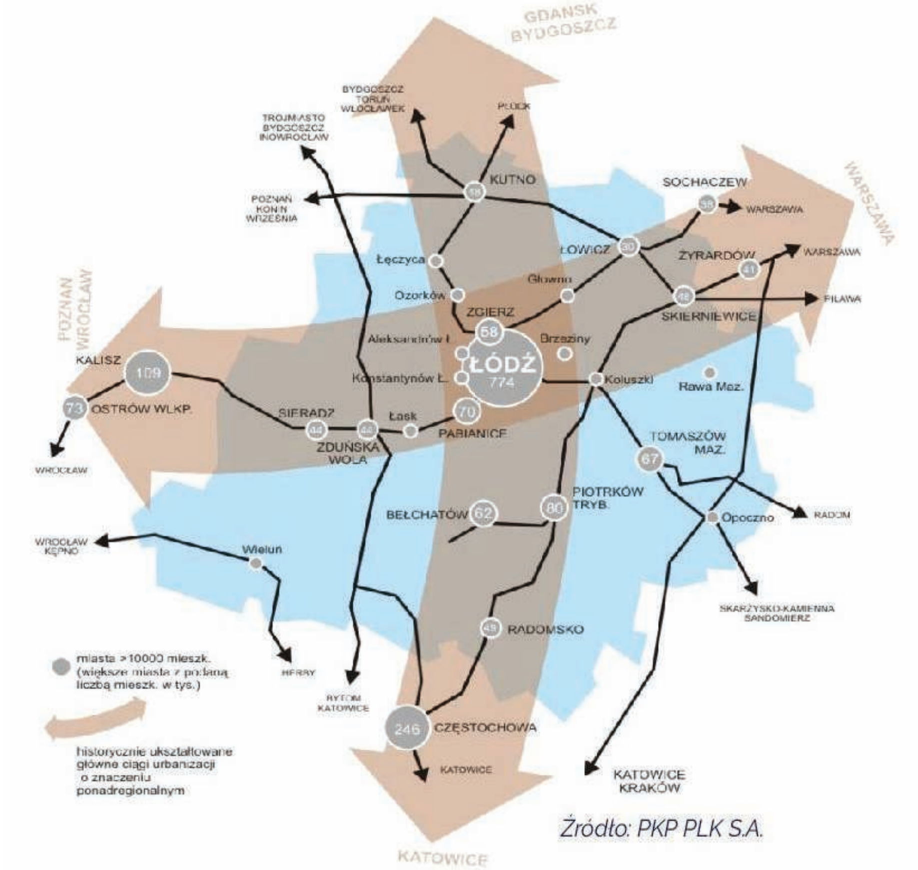
From the outset, the construction of these tunnels has faced numerous challenges. It appears that neither the investor nor the contractor fully accounted for the complexity of the project, including the condition of the buildings above the tunnel route. This is particularly significant given that this is the first railway tunnel of such length in Poland, built under current technical and safety regulations. However, despite the difficulties, the project's completion will radically improve the efficiency of the Łódź Railway Junction and passenger transport within the city and region, making it well worth the wait.

The CPK Project on the horizon

After being abandoned in 2011 under Minister Nowak, the high-speed rail (HSR) project returned to the agenda in 2017, albeit in a slightly modified form. The Concept for the Preparation and Implementation of the Solidarity Transport Hub (CPK) for the Republic of Poland, adopted by the Council of Ministers on 7 November 2017, included not only plans for the central airport but also a rail component. This included 'Spoke No 9', which corresponds to the previously planned 'Y' HSR route from Warsaw through Łódź to Wrocław and Poznań.

The route of this line was ultimately based on Variant 3 from the 2005 CNTK study, with a branching point in Sieradz. This decision remains controversial among some experts, but given the advanced stage of design work and the administrative approvals already secured, reversing it now would put the entire project at significant risk. As a result, rail connections for Kalisz and Ostrów Wielkopolski will rely partly on conventional railway lines, while Wieruszów and Kępno will benefit from improved connections.

Moreover, the HSR project is already underway. CPK has acquired the preliminary design documentation for the HSR tunnel under central Łódź from PKP PLK, which has



***9**. The impact of railway infrastructure investments on the Łódź Railway Junction area*

helped accelerate the planning and preparatory work. The construction of the TBM start and exit shafts for the tunnel boring machine is now in its final stage, and the tender for the HSR tunnel, opened on 20 December 2024, is currently being evaluated by CPK experts.

The integration of the HSR line through Łódź Fabryczna station, which will handle large volumes of passengers on frequent services, combined with the expansion of the Łódź Metropolitan Railway (ŁKA), will lead to a major transformation of the Łódź Railway Junction within the national rail network. Łódź Fabryczna will become a key transfer hub for both long-distance travel and regional transport. Analyses suggest that the capacity of the conventional railway tunnel currently being built by PKP PLK will be fully utilised. The modernisation of conventional railway lines and the introduction of comfortable, new or upgraded rolling stock have already led to a 10% year-on-year increase in PKP Intercity passenger numbers, a strong indicator of further growth once the HSR line becomes operational. With its central location in Poland, Łódź will finally take its place at the heart of the country's railway network. The reduction in travel times on modernised conventional railway lines, combined with the availability of comfortable journeys on new or upgraded rolling stock, has led to a year-on-year increase of approximately 10% in PKP Intercity passenger numbers. This serves as a strong indicator of further growth once the high-speed rail (HSR) line becomes operational. With its central location in Poland, Łódź will finally take its place at the heart of the country's railway network.

Studies on projected growth in rail traffic indicate that the construction of the HSR line will create demand for upgrades to complementary conventional routes. To improve northern access from the Łódź Railway Junction via Zgierz to Kutno, the existing single-track line must be expanded to a double track, with speeds increased to 160 km/h. Additionally, for fast long-distance rail connections, a modernised link between the HSR line and the Central Railway Main Line (CMK) is essential. This would require upgrading the Łódź Widzew – Tomaszów Mazowiecki – Opoczno Południe route to 200 km/h. Both projects are currently under review by PKP PLK.

More than just efficient transport

The enhanced transport connectivity of the Łódź region, resulting from PKP PLK and CPK investments, is just one of the many opportunities these infrastructure projects create. To operate railway services and maintain railway assets, a highly specialised workforce will be required, and Łódź, as a major academic centre, is well positioned to meet this demand. The technical facilities for maintaining high-speed rail (HSR) rolling stock will likely be located in the central part of the 'Y-line', which also points towards the Łódź region as a key location.

Modern rail transport is increasingly digitalised. Rail traffic management systems, train safety solutions, passenger information services, journey planning platforms, ticket distribution, and rolling stock maintenance are all progressively integrating the Internet of Things (IoT), big data, and artificial intelligence (AI). This technological shift presents a significant opportunity for the Łódź region.

One must not forget about the CPK airport itself. Built from scratch in an unconstrained location, it will become not only a hub for airline passengers and a key transfer point for transcontinental travel but also a centre of economic activity, which will rapidly develop around it. International experience shows that areas with strong air, rail, and road connectivity naturally evolve into incubators for the rapid growth of various logistics, service, and innovation-driven enterprises.

However, this development must be carefully planned to fully capitalise on the opportunities presented by the airport's construction. For this reason, CPK has developed a Strategy for the Development of the CPK Surrounding Area until 2044, covering 18 municipalities within the airport's direct impact zone. Once the consultation, review, and approval processes are completed, this document is expected to be adopted by the Council of Ministers, with approval anticipated later this year. At the same time, the Ministry of Development Funds and Regional Policy has initiated work on the Medium-Term National Development Strategy until 2035. One of the proposed National Strategic Intervention Areas (OSI) would be the region surrounding the CPK, encompassing municipalities on both sides of the border between Mazowieckie and Łódzkie voivodeships. In practice, this would mean moving towards the realisation of the once-promoted 'duopolis' concept, and, considering other urban centres along the Warsaw–Łódź corridor, the broader vision of a 'megalopolis.'

Conclusion

The implementation of landmark investments, such as the construction of the CPK airport and Poland's first high-speed rail (HSR) line from Warsaw through Łódź to Wrocław and Poznań, presents unparalleled opportunities for the development of the Łódź region. The impact of the CPK project extends far beyond improved transport connectivity, influencing multiple aspects of regional growth.

The local and regional authorities of Łódź and the Łódź Voivodeship face a significant challenge: to analyse the opportunities, devise effective strategies, and promote the region's strengths to ensure that the opportunities created by the CPK project are maximised to their fullest potential.◀

Integrated approach to the implementation of CCS, transmission and power supply systems on High-Speed Railways in Poland

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Abstract: In the introduction, the article discusses the specifics of CCS, telecommunications, and power supply systems on railway lines, as well as the barriers to effective implementation of these systems to date. It also characterizes the technical specifics of the planned Polish HSR network. The article then outlines the key role of the Eulynx specification in defining the requirements for CCS systems on this HSR network, presents the optimal hardware architecture for this system, and discusses the important role of telecommunications and data transmission systems and their designed technical characteristics. The next system described is the 2x25 kV AC traction power supply, where, in addition to the technical aspects, the succes story is presented regarding the design of this system and the arrangements for its connection to the power transmission grid in Poland. In conclusion, an implementation approach is presented, understood as the optimal split of tenders and contracts for industry packages.

Keywords: *HSR in Poland; Eulynx; ETCS without signals; Interlocking; CTC; SIL4 Cloud; MPLS-TP; 2x25 kV AC Power Supply*

Introduction

Control-Command and Signalling (CCS), telecommunications, and power supply systems, when compared to other components of the multi-disciplinary railway infrastructure, require a uniform approach across the entire high-speed rail (HSR) line under construction and, in some cases, across the entire national railway network. Additionally, their integration with analogous systems in adjacent areas, as well as with centralised (network-wide) systems within each discipline, is far more complex from both technical and organisational-contractual perspectives than in traditional construction sectors, such as track infrastructure. For example, welding rail joints at the boundary of two track contracts is a routine, repeatable process that requires far less conceptualisation than implementing an electronic interface between CCS systems at the boundary of two signalling control areas.

This creates a paradox:

- On one hand, digital systems are currently experiencing the fastest pace of development, with manufacturers introducing new, significant functionalities. As a result, previous versions and generations of these systems quickly become obsolete,
- On the other hand, due to strong interdependencies with existing systems on the railway network, there are major obstacles to deploying the latest system generations. The need to maintain compatibility with legacy systems preserves outdated technologies, acting as a barrier to introducing new functions that could improve efficiency, reliability, and punctuality in railway operations.

Poland's high-speed rail network (HSR), whose first element will be the 'Y' line connecting Warsaw, Łódź, Wrocław, and Poznań, will require different technical solutions than the conventional rail network, primarily due to the higher train speeds. Key requirements include:

- In the Control-Command and Signalling (CCS) sector, ETCS Level 2 must serve as the foundation for train operations, transmitting movement authority information directly to the driver's cab. At speeds above 160 km/h, optical signalling (trackside signals) cannot be relied upon, so high-speed rail lines will not be equipped with signals for mainline operations. This approach was formalised in the November 2023 amendment to the Regulation on detailed conditions for railway traffic management and signalling. However, shunting signals will remain, as current versions of ETCS do not yet fully support supervised shunting movements.
- The design speed of 350 km/h necessitates the use of a 2x25 kV AC traction power supply system.
- In radio communications, system designs (e.g. radio site density) must at a minimum facilitate a seamless migration to the FRMCS system, while wired transmission networks will be based on the MPLS-TP standard.

This means that before the implementation of the aforementioned systems on the HSR network, their suppliers will have to subject the currently available systems to significant development work and enhance them with new functionalities (e.g. adapting the CCS system to a semaphore-free configuration) or entirely new solutions will be applied—ones that have not yet been used in practice in Poland but have been tested in many other countries (e.g. the 2x25 kV AC traction power supply system), which will also require specific implementation work in the domestic market. Taking advantage of the opportunity to introduce new (or significantly modified) systems, it is essential to ensure that they align with the current level of European technical knowledge rather than repeating certain outdated models, both in terms of system architecture and its operation.

Control-command and signalling (CCS) and telecommunications systems

Centralny Port Komunikacyjny sp. z o.o. (CPK), as the entity responsible under current regulations for the construction of new high-speed rail (HSR) lines in Poland, has decided to fully adopt EULYNX standards, which primarily define interfaces between individual components and devices within the control-command and signalling (CCS) system. CPK has been collaborating with EULYNX for approximately two years, and as of 1 January 2025, it has become the seventeenth member of the organisation. EULYNX already includes several major European railway operators, such as the French, Italian, German, Dutch, Belgian, Swiss, Austrian, Norwegian, Swedish, Finnish, and Czech railways (for details, see https://eulynx.eu/about-us/).

A significant part of the EULYNX specifications has been adopted as the basis for work within the 'System Pillar' of Europe's Rail, meaning that they are highly likely to become a requirement in the next major revision of the control-command and signalling subsystems TSI. In addition to the well-known aspect of EULYNX, which is communication interfaces, these specifications also cover other important areas, including cybersecurity.

The EULYNX standardisation not only facilitates integration between systems from different manufacturers, whether in adjacent control areas or across different system layers (e.g. an interlocking system (IXL) from one supplier integrated with a centralised traffic control (CTC) system from another). However, an even more critical aspect is the operational phase of a railway line after its construction or modernisation, where the lifespan of individual CCS system components differs significantly. For example, the lifecycle of an interlocking system (IXL) is considerably shorter than that of most trackside devices. This end-of-life (EOL) issue—where, 15–20 years after delivery, a manufacturer ceases support, stops supplying spare components, etc.—was the primary reason behind the creation of the EULYNX initiative. This challenge is already present at several locations on the Polish railway network and will continue to grow. If all connections between an interlocking system (IXL) and other CCS components (e.g. trackside devices, which may still be fully functional after 15–20 years) are proprietary to the manufacturer, and the infrastructure manager has neither knowledge of them nor intellectual property rights, then replacing an EOL interlocking system with a new one from any supplier—while retaining the rest of the CCS system—becomes impossible. The infrastructure manager is therefore forced either into non-competitive direct negotiations with the previous supplier, which usually does not result in a reasonable price for replacing only the interlocking system (IXL), or into a complete replacement of the entire CCS system at the station (rather than just the IXL) if they wish to maintain a competitive procurement process, which means an even greater financial outlay. Systems delivered in accordance with EULYNX specifications will naturally be free from this issue.

To achieve these objectives, EULYNX had to precisely delineate the functions performed by individual components of the CCS system, including interlocking systems (IXL) and object controllers (OC). The EULYNX approach aligns with modern CCS system architectures, where downstream transmission from the IXL is carried out via fibre-optic cables, eliminating any limitations on the maximum transmission distance. Replacing thick bundles of copper cables running from each signal box to individual trackside devices—which limit this distance to 6.5 km, even with significantly increased cable cross-sections—with fibre-optic transmission, while supplying power to the OC and trackside devices locally (i.e. to a container or cabinet housing the OC), will greatly simplify the system and enhance its reliability.

The simplicity and resulting reliability of the CCS system on the HSR network are also supported by the limited number of trackside device types. While point machines and axle counting-based occupancy detection systems are essential for HSR operations, the role of trackside signalling is marginal (limited to shunting signals at selected control points), and level crossing protection systems will not be used at all.

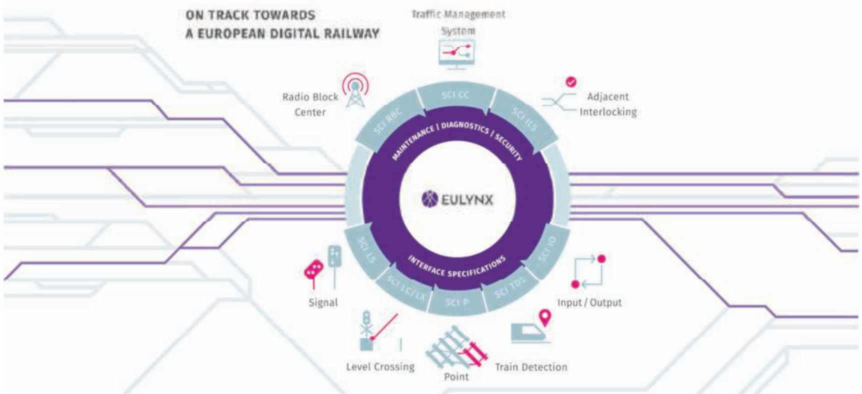
Summarising the above considerations, the final preferred architecture of the CCS system on the HSR network is emerging, in which a single IXL module will cover a relatively large area, approximately 150 km of railway line (most likely corresponding to the area of one CTC module and one Radio Block Centre (RBC)). Decentralised OC containers/cabinets will be located near each major cluster of trackside devices, with 2–4 OC containers/cabinets for a small station and up to a dozen or more at a large station.

A further step in improving the reliability of the CCS system, based on large IXL modules and decentralised OCs, is ensuring geographic redundancy of modules that are critical to the continuity of railway operations, as well as operator workstations. It should be recalled that, to ensure the required level of safety, CCS systems inherently use independent processing on at least two hardware channels, with consistency checks (the so-called '2-out-of-2' structure). Meanwhile, to achieve the required reliability, two such sets are typically installed at a given location (e.g. in a signal box), meaning a 2x'2-out-of-2' structure, with strict requirements for switchover time to the backup set in the event of a failure of the primary set. At first glance, such a structure may seem sufficiently over-dimensioned, but it is completely vulnerable to failure scenarios where an entire building, along with the equipment inside, becomes unavailable. This can occur not only in extreme cases such as natural disasters or war, but also in more mundane and likely situations—for example, if a fire alarm is triggered and, upon the arrival of the fire brigade, the first action is to switch off the building's main fire protection power switch (PWP). This would immediately render the CCS system in the entire area controlled from that building unavailable, regardless of the number of redundant power sources within the building or the hardware redundancy of the CCS system itself. The solution to this issue is to place the backup IXL set in a different geographic location, along with the necessary number of backup operator workstations. One could imagine adding a third backup set in a third independent location, and so on. However, it is important to balance increasing investment costs against the expected improvement in reliability.

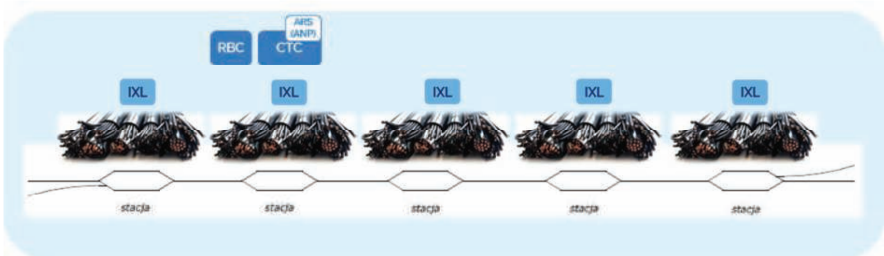
The target state is that with 2–3 OCS (Operations Control Centres) on the 'Y' line, each OCS will be able to control any traffic control point. This configuration is fully achievable based on the experience of other European infrastructure managers.

In this architecture, the fibre-optic transmission network no longer functions as a separate entity alongside CCS systems, primarily serving to connect adjacent CCS systems at different stations. Instead, it becomes an integral part of these systems, as it is responsible for linking the IXL with (sometimes very distant) object controllers (OC), as well as connecting the primary and backup IXL sets (and similarly for CTC and RBC). As a result, the transmission network becomes an inherent component of the CCS system, and its reliability becomes crucial to the overall system's reliability. A physical ring topology at each level:

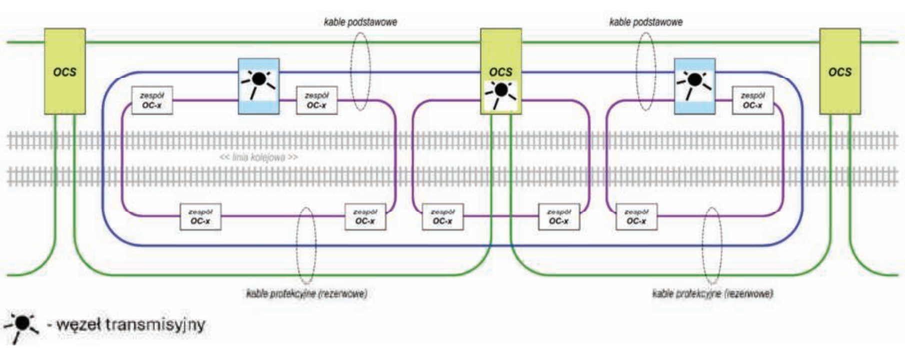
- in the backbone network connecting different OCS locations;
- in the network linking the OCS with control points within its area;



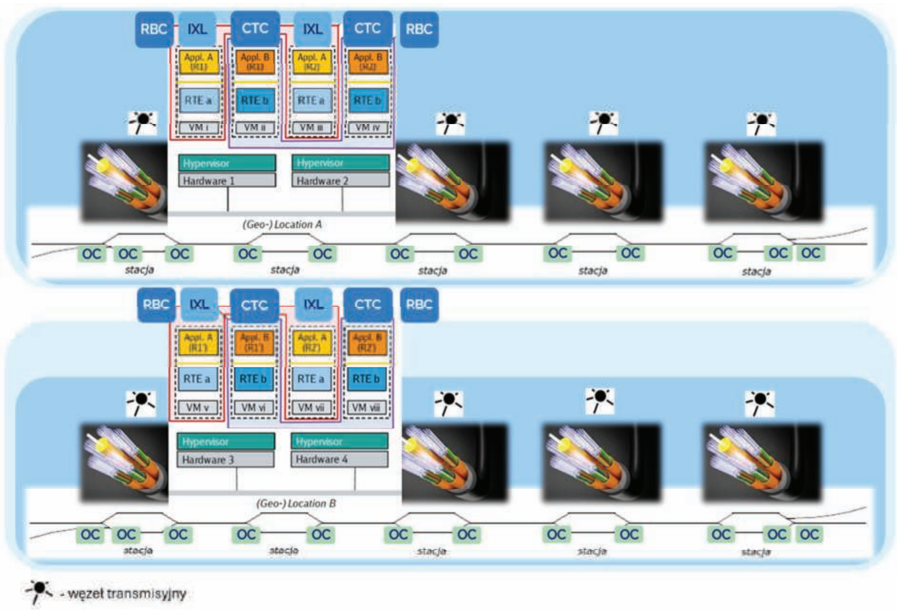
1. Systems, Devices, and Interfaces Covered by EULYNX Specifications (Source: eulynx.eu)



2. Graphical Illustration of the Typical Legacy Architecture of a CCS System on a Railway Line Section (With an interlocking system (IXL) located at each station's signal box, transmission is distributed via bundles of multi-core copper cables over distances of up to several kilometres)



3. Schematic Illustration of Different Levels of the Transmission Network (The indicated connections do not necessarily require separate cables—they may be dedicated fibres within a single cable—but the ring topology must be maintained.). Source: CPK internal regulations



4. Graphical Illustration of the Target CCS System Architecture. (At individual stations, only external devices and their associated object controllers (OC) are located in a decentralised manner within containers/cabinets, along with data transmission nodes and power supply. The interlocking system (IXL), centralised traffic control (CTC), and Radio Block Centre (RBC) are located in the OCS for a given area, with their backup sets housed in the OCS of the neighbouring area, and vice versa)

- in the network connecting the telecommunications node at a control point with individual object controllers (OC),

- combined with the MPLS-TP standard, will ensure the required reliability.

It is natural to associate this CCS system architecture with the architecture of non-railway IT systems, which are based on two or more redundant data centres. The open question remains whether safety-critical CCS applications such as IXL, CTC, and RBC should remain tightly linked to hardware (as is currently the case), or whether, in line with European trends, there should be a move towards separating the 'business logic' of these applications from the hardware they run on. Without a doubt, such a separation would be another step toward solving the issue of End-of-Life (EOL) systems. It would also significantly impact the approval process, as only the interlocking application and the SIL4 safety layer would need to be certified, while Commercial Off-the-Shelf (COTS) hardware could be cyclically replaced. However, this would require regulatory changes at the level of the relevant ministerial decree. That said, considering the regulatory changes already implemented in railway legislation for HSR over the past 3–4 years, such a transition does not appear to be a major legislative challenge.

2x25 kV AC traction power supply

The existing 3 kV DC traction power system on the Polish railway network is insufficient for train speeds exceeding 250 km/h. For this reason, the 2x25 kV AC power supply system will be implemented on the HSR network.

This system imposes an asymmetrical load on the power grid. However, contrary to some incorrect claims, it is not a single-phase load. The train itself is a single-phase load, but a single traction transformer already loads two phases, and a complete 2x25 kV AC traction substation, which contains at least two traction transformers, acts as a three-phase load (although, as mentioned, an asymmetrical one).

It is precisely this asymmetry—rather than the total power demand—that necessitates relatively strong connection points between 2x25 kV AC traction substations and the National Power System. For many years, theoretical discussions on the development of Polish HSR often focused on this issue. Some argued—though the specific reasoning was never clearly justified—that Polskie Sieci Elektroenergetyczne S.A. (PSE), as the Transmission System Operator, and especially Distribution System Operators, would refuse to connect this type of power load to their networks, thereby preventing the construction of HSR in Poland.

However, concrete actions in this area—carried out in accordance with the Energy Law Act and its implementing regulations—have only been undertaken by CPK.

First, in November 2022, thanks to strong cooperation between CPK and PSE, the investments necessary for connecting the HSR power supply were included in the Transmission Network Development Plan for 2032. Then, in May 2023, CPK submitted applications to PSE for the connection of five traction substations—two on the Warsaw–Łódź section and three on the Łódź–Wrocław section. As a result, in May 2024, the connection conditions were issued. The connection conditions for the two substations on the Sieradz–Poznań section are expected in March 2025. Interestingly, these two facilities will be connected to the 110 kV network—one via PSE S.A. and the other via the distribution system operator Energa-Operator S.A.—while maintaining the use of conventional single-phase traction transformers. The 110 kV network nodes in these locations were found to be sufficiently robust for connection.

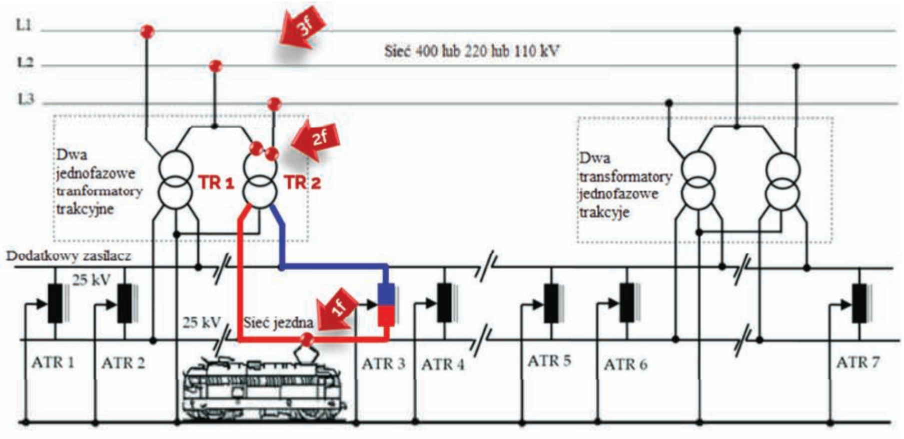
At this point, it is worth mentioning that power electronics converters are now available that allow asymmetrical loads to be connected even at weaker network points. However, these converters are significantly more expensive to purchase and operate, and their lifespan is shorter than that of a conventional transformer. Fortunately, on the 'Y' line, due to the availability of a sufficiently strong power grid nearby, such converters were not necessary.

Naturally, the formal procedures were preceded by comprehensive technical analyses. Due to the unconventional nature of the connected load, CPK commissioned a broad-ranging expert study to assess the impact of the new loads on all relevant parameters of the National Power System (KSE). The goal was to ensure, in cooperation with energy sector partners, that this impact would remain within permissible limits. Based on train movement simulations and the resulting one-second power profile, the following analyses were conducted:

- Power quality analysis, including:
  - o Supply voltage asymmetry analysis,
  - o Harmonics analysis,
  - o Voltage fluctuation and rapid voltage change analysis;
- Load flow analysis;
- Short-circuit analysis (considering both minimum and maximum short-circuit power).

The study considered:

- Two time horizons for the development of the National Power System (2028, 2033);



***5**. Conceptual Diagram of the 2x25 kV AC Traction Power Supply System*

***6**. 2x25 kV AC Traction Substations on the 'Y' Line (Red – 400 kV voltage, Green – 220 kV voltage, Yellow – 110 kV voltage)*

- Two balance periods (summer peak, winter peak);
- Two renewable energy generation scenarios (low, high).

This resulted in a total of 2 × 2 × 2 = 8 scenarios for the National Power System.

On the traction power side, 32 scenarios were considered. This number stems from the fact that, in addition to the standard operating state, contingency scenarios N-1 (failure of a single key system component, such as a traction transformer) and in some cases N-2 (failure of two key components) were also examined.

To perform these analyses, the expert entity engaged by CPK imported data from the computational model provided by PSE (*.kdm files, PLANS software) into software capable of asymmetry analysis (in this case, PowerFactory). The next step involved recreating the geometry of the phase conductors of transmission lines within the model to account for naturally occurring system asymmetry. Finally, for this refined model, unbalanced power flow calculations were carried out, incorporating the loads from the newly constructed traction substations across all the above scenarios. It should be emphasised that this was the first and, so far, the only such comprehensive analysis concerning asymmetrical loads in Poland.

A crucial factor in successfully securing connection conditions for the 2x25 kV AC traction substations to PSE's network was CPK's holistic and system-wide approach from the outset. This was carried out within a dedicated project, independent of the highly fragmented division applied in designing the 'Y' line, which was split into approximately ten sections. A crucial factor in successfully securing connection conditions for the 2x25 kV AC traction substations to PSE was CPK's holistic and system-wide approach from the outset. This was carried out within a dedicated project, independent of the highly fragmented division applied in designing the 'Y' line, which was split into approximately ten sections. A single project team within CPK is responsible for all 2x25 kV AC substations, supported by one expert entity conducting analyses across the entire 'Y' corridor. Communication with key stakeholders, particularly PSE, takes place within a single coordination stream. A fragmented approach would have been ineffective: technically, (it would have been impractical to consider mutual redundancy between substations over shorter sections); procedurally, conducting multiple isolated analyses instead of a single, cohesive study would have been inefficient; and organisationally, if stakeholder communications were split into separate channels for each substation, handled by different individuals, it would have caused coordination issues.

A single project team within CPK is responsible for all 2x25 kV AC traction substations, supported by one expert entity conducting analyses across the entire "Y" corridor. Communication with key stakeholders, primarily PSE, takes place within a single coordination stream. A different approach would be ineffective—technically (how could mutual redundancy between substations be considered over short sections?), procedurally (why conduct multiple sectional analyses instead of one cohesive study?), and organisationally (if stakeholder communication were split into separate streams for each substation, handled by different individuals).

Implementation approach

The construction of HSR in Poland is on the verge of transitioning from the design phase to the implementation phase. At this stage, a key challenge is ensuring the appropriate division of the contracted scope of construction works into sector-specific packages. This should take into account, among other things:

- The need to ensure consistent and uniform technical solutions, which will facilitate the future operation and maintenance of the railway line—for example, a standardised type of traction network;
- The specific nature of certain disciplines and systems, which can only be correctly designed and built over long sections that form a logical, self-contained whole, as discussed earlier;
- The need to integrate equipment from various disciplines into a unified control and management system;
- Clear responsibility of individual contractors for ensuring that their subsystem complies with requirements and standards, as well as for the formal certification process of structural subsystems (Infrastructure, Control-Command and Signalling, Energy) concerning sections that form a functional whole from the perspective of a given subsystem;
- The specific nature of constructing a new railway line (as opposed to modernising an existing line), where works in different disciplines generally proceed sequentially, rather than simultaneously in multiple phased stages.

For these reasons, CPK will award contracts for the 'Control-Command and Signalling' and 'Energy' subsystems separately, with each procurement covering the longest possible section of the HSR line. The optimal solution would be to align the available funding with the mechanisms provided in the Public Procurement Law, so that these tenders could cover the entire 'Y' corridor—with some sections included as part of the core contract and others as an option right. ◀

Track superstructure solutions for High Speed Rail

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Abstract: The first concepts for the construction of High-Speed Rail (HSR) in Poland date back to 1995. However, it is only in recent years that these projects have begun to take concrete shape. A key investment within the HSR program is the "Y" line, connecting Warsaw, Łódź, Poznań, and Wrocław, where trains will reach speeds of up to 320 km/h. An essential infrastructure element is the construction of the long-distance tunnel in Łódź, which will become part of a multimodal railway hub. Celebrating its 20th anniversary in 2024, TINES has played a significant role in the development of modern railway track structures in Poland, particularly in slab track construction. Its innovative solutions help reduce vibrations and noise while enhancing infrastructure durability. TINES actively participates in infrastructure projects, adapting its products to meet EU and national technical standards. However, regulatory and legal challenges continue to pose a risk to the full utilization of Polish companies' potential in HSR construction. Nevertheless, the industry's commitment and growing expertise inspire optimism regarding the implementation and future development of Poland's high-speed rail system.

Keywords: *High-Speed Rail; Ballastless Track; Infrastructure Development*

Introduction

The first concepts for the construction of high-speed rail (HSR) lines in Poland date back to 1995 with the Directional Programme for High-Speed Rail Lines in Poland [1]. Thirty years ago, the assumptions regarding the development of HSR lines in Poland seemed rather unrealistic. However, in retrospect, it can be concluded that they laid the initial conceptual foundations for creating an efficient and integrated railway transport system in Poland. Currently, the investment priority of Central Communication Port (CPK) remains the so-called 'Y' (HSR 'Y') line, connecting Warsaw and Łódź with Poznań and Wrocław, where trains will reach speeds of 300–320 km/h [2]. As part of the ongoing tender procedure for the construction of a long-distance tunnel on railway line no. 85 in Łódź, the construction of a ballastless railway tunnel is planned from the 'Fabryczna' chamber to the 'Retkinia' chamber, including the necessary infrastructure. The planned structure will connect with the multimodal Łódź Fabryczna railway station, which was commissioned on 11 December 2016, creating a central railway hub for the planned 'Y' high-speed rail network. The geometric parameters of the future double-track high-speed rail line, located within one of the largest and most modern railway stations in Europe, were already adapted to HSR requirements in 2016.

TINES 20th anniversary celebrations

The year 2024 marked the 20th anniversary of TINES, a period of reflection and intensive efforts to promote Polish manufacturers, technical universities, research institutes, engineering associations, business chambers, and key clusters. Throughout a series of industry meetings, we shared knowledge and experience gained both in Poland and internationally, developed in collaboration with infrastructure managers, designers, construction contractors, and the Polish scientific and research community. The TINES anniversary was warmly received, earning honorary patronage from the most important technical institutions in the country—see Figure **1**.

The beginnings of ballastless track in Poland

One of TINES' key achievements was introducing systematic solutions for ballastless track superstructures in Poland. Modern transport infrastructure increasingly prioritises failure-free rail track surfaces, and TINES has consistently sought to meet these expectations by offering comprehensive systems tailored to new requirements. The first major railway contract in which a modern ballastless track system was implemented—designed to reduce vibrations and noise—was the reconstruction of the Warsaw cross-city tunnel in 2006—see Photograph **2**. The construction featured prefabricated rail block supports encased in an EBS (Embedded Block System) polymer shell. The supplied components included a concrete support block with a rail fastening system, a concrete socket with an additional vibro-isolating pad at its base, and a permanently elastic polymer casing connecting both concrete elements. The specialised prefabricated components were installed using a 'top-down' method. Rails were fastened to the prefabricated elements delivered to the tunnel, after which assembly work commenced. The prepared rail tracks were secured in adjustment frames, which lifted the track grid, enabling precise vertical and horizontal alignment. The final stage involved pouring the track slab, permanently integrating all components with the structure. Once the concrete had set, the assembly frames were dismantled, completing the work. Train traffic on the new track surface began in 2007.

Despite the challenging operating conditions in the leaky tunnel, which was commissioned in 1933, on-site inspections carried out by the TINES team, in cooperation with the Railway Line Plant of PKP PLK S.A. in Warsaw, confirm the validity of the adopted solutions and the fault-free operation of the track superstructure for nearly 20 years. Based on positive technical assessments from both domestic and international infrastructure managers, the TINES® EBS embedded block support system used in ballastless track superstructures continues to evolve in response to the growing demand for reliable, long-lasting, and low-maintenance infrastructure.

When using ballastless track on earthworks structures (such as embankments or cuttings), where settlement may occur, additional stabilisation and reinforcement work must be carried out in the substructure—i.e., directly beneath the track slab—as well as additional reinforcement of concrete elements. However, this is not required in tunnels, where, after installation, the track substructure slab forms a uniform monolithic structure with the tunnel tubing. The key advantages of the TINES® EBS system include vibration and noise reduction, as well as low maintenance costs throughout its operational lifecycle, although this comes at a higher initial cost compared to a ballast track. The structural solution incorporating the embedded block support system is designed for a service life of no less than 50 years, ensuring a stable track geometry. This directly contributes to a high level of travel comfort while significantly improving the condition and durability of other track components and reducing rail wear.

A turning point in the development of this track superstructure was the first-ever installation of railway turnouts in a ballastless track system in Poland. The system solution designed by TINES for a double track connection, consisting of three standard right-hand turnouts of type 60E1-300-1:9, one left-hand turnout, and a diamond crossing of type 60E1-1:4.444 used to connect two adjacent tracks, was implemented in 2012 on the newly built railway line No 440, linking the Warszawa Służewiec station with the Warszawa Chopin Airport station—see

1. Honorary Patrons of the TINES 20th Anniversary Celebrations

Photograph **3**. A series of studies and measurements conducted by the Railway Research Institute concluded that the embedded block support system could be used in turnouts and railway crossings for all types of turnouts made from Vignole rails and special rail profiles (in switch points and crossings) in tracks with gauges of 1,435 mm or 1,520 mm [3].

The installation of ballastless track superstructures has become a standard solution for demanding investment projects undertaken by railway infrastructure managers in Poland. TINES' involvement in the construction of the cross-city tunnel in Łódź, together with the Łódź Fabryczna railway station, which forms part of the future High-Speed Rail network, marks the beginning of a transformation in the Polish railway system—see Photograph **4**.

The long-term investment plan of the Central Communication Port includes the construction of the railway component using modern ballastless track superstructure solutions.

TINES® EBS Fastening System in Light of EU Requirements – TSI relating to the 'infrastructure' subsystem

The compliance of solutions used in the railway transport market within the European Union is based on the so-called 'legislative pyramid,' which includes the following elements:

1. Interoperability directives, defining essential requirements,
2. Technical Specifications for Interoperability (TSI), defining fundamental parameters,
3. Detailed documents (standards and technical specifications) referenced in the TSI specifications as mandatory, as well as harmonised standards (not referenced in TSI specifications), the application of which remains voluntary but ensures presumed compliance with essential requirements [4].

Until recently, the definition of the TINES® EBS system in normative terms remained a subject of debate. The solution has been proven to comply both with the standard PN-EN 13481-5+A1:2017-04 [5], listed by the President of the Office of Rail Transport, and with the latest update PN-EN 13481-5:2022-12 [6], which, as of 2022, explicitly recognises this as the appropriate reference document. Until recently, the definition of the TINES® EBS system in normative terms remained a subject of debate. The solution has been proven to comply both with the standard PN-EN 13481-5+A1:2017-04 [5], listed by the President of the Office of Rail Transport, and with the latest update PN-EN 13481-5:2022-12 [6], which, as of 2022, explicitly recognises this as the appropriate reference document. According to Commission Regulation (EU) No 1299/2014 [7], the TINES® EBS fastening system (see Illustration **5**) is classified as an 'interoperability constituent.' Section 5.3.2. The rail fastening systems, paragraph 2 of the document details the specific technical requirements that the solution must meet. Although the system was introduced to the Polish market in 2006, it is continuously developed, monitored, and maintained to ensure production quality by the TINES Technical Department. The intensive work carried out between 2021 and 2024 has allowed us to fully meet all the requirements outlined in the TSI Infrastructure. To confirm compliance with the updated normative requirements concerning fastening system operational performance, we conducted a full-scale structural type test using only the most up-to-date procedures based on harmonised standards—ensuring full conformity with essential requirements.

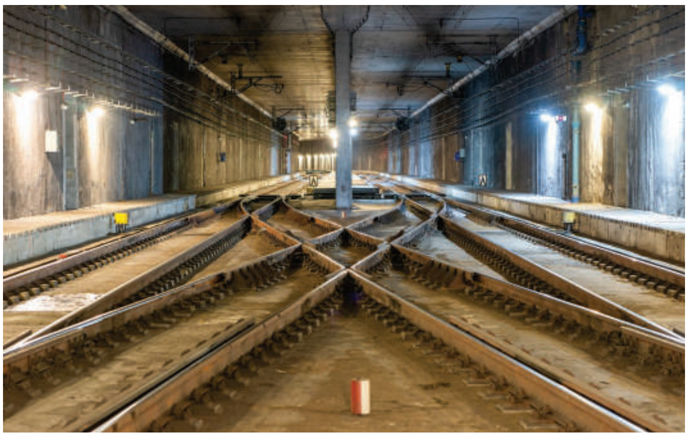
The achievements of 2024 marked a groundbreaking milestone not only for TINES as a company but also for the intellectual capital of Poland's railway sector. Following comprehensive research programmes conducted for the TINES® EBS and TINES® EBS-R embedded block rail supports, the company obtained:

1. A Technical Opinion on the fastening system – TINES® EBS system, dated 13 December 2024, which, for the first time, recommends a solution developed by a Polish manufacturer: '(...) the TINES® EBS rail fastening system, in the variants of TINES® EBS and TINES® EBS-R embedded block rail supports, may be used in tracks designed for high-speed trains (V > 250 km/h)' [8], and
2. A Permanent Type Compliance Certificate, issued on 20 December 2024, confirming that: '(...) the structure meets the requirements and operational properties specified in technical specifications and standardisation documents (...)' [9].

Is the construction of high-speed rail truly an opportunity for Polish companies?

The preparation and execution of infrastructure projects represent one of the key challenges for both Poland's public administration and its technical community. As representatives of the latter, we do not see any technological or competency-related obstacles that could limit the participation of Polish companies in the construction of high-speed rail (HSR)—see Photograph 5. Nevertheless, the market entry barrier remains high, primarily due to rapidly changing formal and regulatory requirements, which

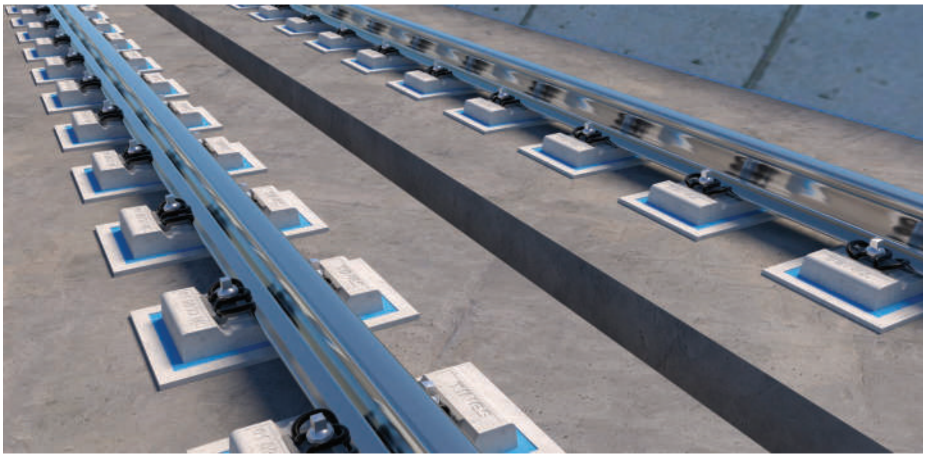
2. Warszawa, cross-city tunnel, 2023, own materials



3. Warsaw, tunnel leading to Chopin Airport, 2024, own materials

4. Cross-city tunnel in Łódź, 2015, TINES Rail S.A.

5. Embedded Block Rail Support – TINES® EBS HR 60E1 MS.B



6. Track Superstructure with the TINES® EBS System

make it difficult for Polish firms to fully prepare for tender proceedings on equal terms. The Technical Standards of Central Communication Port (CPK) [10], which have been undergoing continuous updates since 2021, have already reached their sixth version. The most recent version of the document was published on 15 January 2024, imposing new requirements just six months before the launch of the tender procedure for the construction of the tunnel on railway line 85, from the Fabryczna chamber to the Retkinia chamber, along with the necessary infrastructure for the tunnel, chambers, and railway line.

Some of these requirements may appear excessive and not entirely justified. Notably, certain provisions are not included in the technical specification for interoperability (TSI) relating to the 'infrastructure' subsystem [7] or the technical specification for interoperability relating to 'safety in railway tunnels' [11], both of which define the technical standards for designing and constructing HSR tunnel infrastructure. These requirements are also absent from industry standards regarding the operational criteria for fastening systems or the design of ballastless track systems, subsystems, and components. Yet, these documents were developed within the framework of European CEN standards (European Committee for Standardization) and adopted by PKN (Polish Committee for Standardization) as national standards.

Summary

The construction of Central Communication Port (CPK) and the development of high-speed rail (HSR) present a unique opportunity for the dynamic growth of Polish enterprises, research institutes, and laboratories, as well as the implementation of innovative solutions—ultimately strengthening the entire national construction sector. The responsible execution of strategic infrastructure investments will yield tangible benefits for the Polish economy. There are well-documented cases of successful implementations of new railway track structures, which initially were used only locally but, thanks to positive operational experiences and high quality, later gained international recognition and became a standard solution for high-speed rail lines. A similar process can unfold in Poland. We have the technological and engineering potential to develop our own solutions for HSR and, following the example of other countries, to promote them at the European level. As TINES, we fully meet all regulatory requirements for speeds exceeding 250 km/h (see Illustration **6**). The only thing the industry lacks is hands-on experience in delivering such projects. However, every company that boasts such expertise today once had its first opportunity. Let us work together to develop the know-how and competencies of Polish enterprises. ◀

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The operation of ETCS in high-speed lines - legal requirements

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Abstract: This article discusses the national requirements for operating ETCS at speeds above 160 km/h. Particular emphasis is placed on the amendment to the 2023 Traffic and Signaling Regulation, which allows for operation in ETCS without classic semaphore signaling. This change is in line with the European trend to create the so-called ERTMS radio system, as mentioned in the European Commission Regulation of June 2024, which is a system with full detection without the need for trackside signaling. The second part of the article focuses on the experiences of PKP PLK regarding the operation of the ETCS system at speeds above 160 km/h.

Keywords: *ETCS; Signalling; Legal requirements; TSI Control, Comand and Signalling*

Legal Aspect

According to the applicable regulation on the general conditions for railway traffic management and signalling, operating at speeds above 160 km/h in Poland is only possible with the ETCS system. This means that installing ETCS on a given railway line is essential for running trains at speeds above 160 km/h, and in the event of a failure of either trackside or onboard ETCS equipment, the maximum permitted speed is reduced to 160 km/h.

One of the most recent amendments to the Regulation on the general conditions for railway traffic management and signalling of 2023 [1] has established a legal framework for improving railway operations using the ETCS system, particularly on high-speed lines and in mixed traffic operations, meaning both ETCS-equipped and non-ETCS-equipped trains. The most significant changes introduced by the amendment include:

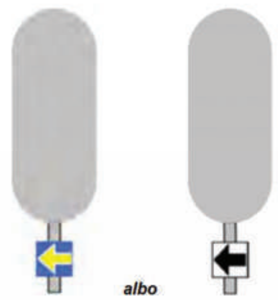
1) Expansion of the definition of a block section – in addition to the current definition, where a block section starts or ends at a traffic control post or an automatic block signal, the amendment includes a block section that starts or ends at an ETCS indicator (W ETCS 10 or the newly introduced W ETCS 11). A block section without a semaphore at its beginning or end is referred to as an 'ETCS block section' (§ 25(7) of the amended regulation). Furthermore:
   - If multiple ETCS block sections exist between a given semaphore and the next one, the proceed signal at the semaphore (applicable to non-ETCS trains) may only be displayed if all those ETCS block sections are unoccupied, meaning without changes to the current traffic management rules,
   - An ETCS-equipped train may receive movement authorisation as soon as one ETCS block section is clear.
2) Introduction of the ETCS block section definition – the use of ETCS block sections can increase line capacity by allowing train movements not only within block sections defined by signals but also based on newly introduced ETCS indicators: W ETCS 10 and W ETCS 11,
3) Clarification of the train dispatching process by the traffic controller;
4) Approval of the following configurations for equipping railway lines with ETCS system devices:
   - Trackside signalling and ETCS devices installed in parallel, allowing both systems to operate simultaneously,
   - Trackside signals remain installed, but when ETCS equipment is operational, train movements rely exclusively on ETCS, with signals being turned off (this option requires the trackside equipment to have a function that allows distinguishing between ETCS and non-ETCS-equipped trains),
   - No trackside signalling, with train movements fully managed by the ETCS system;
5) Introduction of the SE signal: 'Proceed according to the indications of the ERTMS/ETCS system' to facilitate the second of the above configurations;
6) Definition of the W ETCS 11 indicator ('ETCS Location Marker'), specifying its placement and required driver response. Further clarification of the placement and required response to the W ETCS 10 ('ETCS Stop Marker');

The discussed amendment to the regulation aligns with the broader European trend—to achieve rail system interoperability, legislative efforts at the European level are aimed at ensuring that, within the construction of new railway lines (or modernisation of the 'Control-Command and Signalling' subsystem), only ETCS Level 2 is installed, without national signalling systems or Class B systems [2].

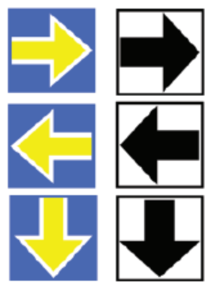
Given this, national regulations should already be adapted to the objective of achieving rail system interoperability, particularly since the safe implementation of new solutions—both legislatively and technically—is time-consuming, due to complex technical challenges.

According to the new Regulation (EU) 2024/1679 of the European Parliament and the Council of 13 June 2024, concerning EU guidelines for the development of the trans-European transport network (TEN-T) and repealing Regulation (EU) No 1315/2013, the ERTMS radio system must be implemented across the core and comprehensive TEN-T network [3].

This refers to an ETCS Level 2 system with



***1**. SE signal*
Source: Regulation of the Minister of Infrastructure of 20 October 2023 amending the Regulation on the General Conditions for Railway Traffic Management and Signalling (Journal of Laws 2023, item 2474).



***2**. W ETCS 10 and W ETCS 11 indicators*
Source: Regulation of the Minister of Infrastructure of 20 October 2023 amending the Regulation on the General Conditions for Railway Traffic Management and Signalling (Journal of Laws 2023, item 2474).

full or limited detection, which does not require trackside signals and uses a Class A radio communication system (GSM-R/FRMCS) for data transmission between trackside and onboard equipment.

The European regulation mandates the deployment of the ERTMS radio system on new TEN-T lines from 2030, on existing TEN-T lines from 2040, and requires that the entire TEN-T network be equipped with ERTMS radio by 2050.

The solutions introduced in the amendment are intended to enable the construction of high-speed railway lines operating at 250–350 km/h and to enhance interoperability by allowing ERTMS/ETCS Level 2 to be used in a configuration without trackside signals.

Operation of the ETCS System at speeds above 160 km/h on the PKP Polskie Linie Kolejowe S.A. network

Currently, train operations at speeds up to 200 km/h are conducted on the PKP Polskie Linie Kolejowe S.A. (PKP PLK) network, using both ETCS Level 1 and ETCS Level 2. The first implementation of ETCS for speeds exceeding 160 km/h on the PKP PLK network was the deployment of ETCS Level 1 on the Central Railway Main Line (CMK, line no. 4, Grodzisk Mazowiecki – Zawiercie section), allowing for speeds of up to 200 km/h.

ETCS Level 1 enabled train operations above 160 km/h while being a more cost-effective installation solution compared to ETCS Level 2. However, the implementation of ETCS on the CMK posed significant challenges due to the mixed traffic operations on the PKP PLK network. The system had to be installed as an 'overlay' on the existing basic railway traffic control equipment, which was originally designed for a maximum speed of 160 km/h for conventional (non-ETCS) trains.

Based on analyses considering spot transmission of data in ETCS Level 1, block section lengths, and line block capacity, the maximum speed for the installed ETCS system was set at 200 km/h.

At the time of ETCS installation on the CMK, the only rail vehicle in Poland technically and formally capable of operating at speeds of up to 200 km/h was the ED250 (maximum operating speed of 250 km/h; currently, this includes the EU200, capable of 200 km/h, and Siemens Vectron).

During ETCS testing on the CMK, it was found that the onboard ETCS system in the ED250 train calculated braking curves in an excessively restrictive manner. Additionally, the braking curve calculation method in the onboard ETCS system—which followed Baseline 2, Model 2—was not harmonised at the European level.

To avoid unnecessary braking interventions caused by the onboard ETCS system's braking curve calculations, speed limits at certain locations on the CMK ETCS system were set below 200 km/h.

The ETCS Level 1 system on the Central Railway Main Line has been in operation at speeds of up to 200 km/h since December 2014.

Currently, a project for the installation of ETCS Level 2 is underway on the Central Railway Main Line (CMK), which will result in the decommissioning of ETCS Level 1 and an increase in the operational speed to 250 km/h. The project includes the centralisation of traffic control, where a more than 200-kilometre section of the line will be managed by a single local control centre along with a single Radio Block Centre (RBC).

Another railway line where ETCS is in operation at speeds above 160 km/h is line no. 9 (E 65 corridor, Warsaw – Gdynia section), where ETCS Level 2 has been implemented. Train operations on line No 9 are conducted at speeds of up to 200 km/h, determined by the infrastructure parameters. As a system that provides continuous transmission of Movement Authorities (MA) to onboard equipment, ETCS Level 2 minimises the impact of the existing traffic control system configuration (such as block section length and line block capacity) on the maximum operational speed.

However, the installation of ETCS on line no. 9, taking into account experience from the operation of ED250 trains, required adjustments in the configuration of level crossing systems. The ETCS Level 2 system on line no. 9 has been in operation at speeds of up to 200 km/h since December 2020.

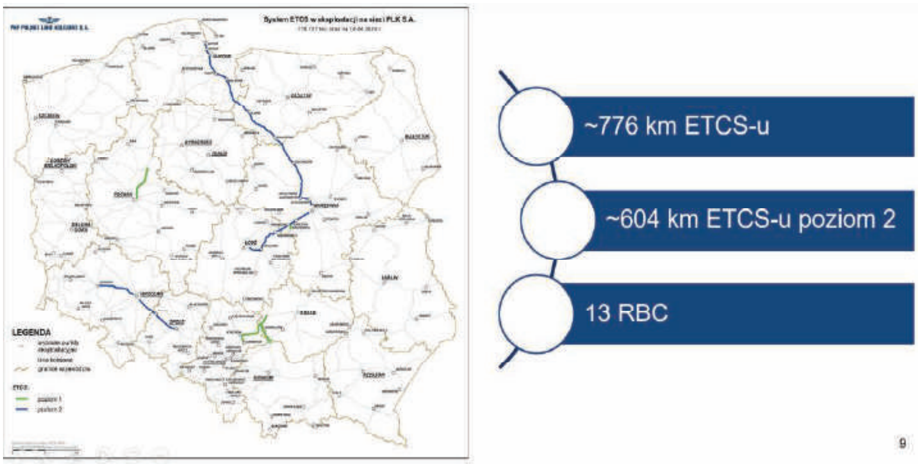
Based on PKP Polskie Linie Kolejowe S.A.'s experience, when operating trains above 160 km/h with ETCS Level 1, the key challenge is finding the right balance between maximum speed and line capacity, particularly in cases of mixed traffic operations on a given railway line. ◀

Source materials

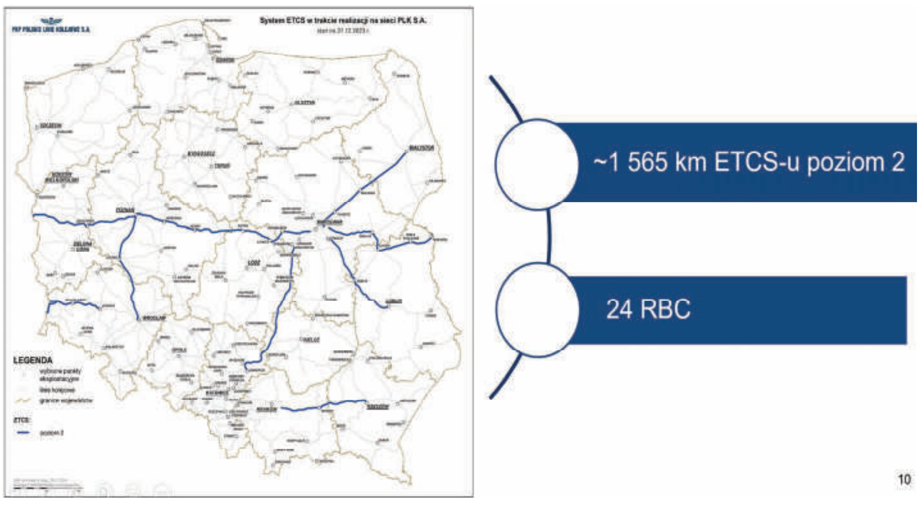
[1] Regulation of the Minister of Infrastructure of 20 October 2023, amending the regulation on the general conditions for railway traffic management and signalling, Dz.U. [Journal of Laws] of 2023, item 2474.

[2] Commission Implementing Regulation (EU) 2023/1695 of 10 August 2023 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919.

[3] Regulation (EU) 2024/1679 of the European Parliament and of the Council of 13 June 2024 on Union guidelines for the development of the trans-European transport network, amending Regulations (EU) 2021/1153 and (EU) No 913/2010 and repealing Regulation (EU) No 1315/2013 (Text with EEA relevance).



3. Lines currently operating the ETCS system, both Level 1 and Level 2
Source: Author's own materials



4. Lines currently undergoing the installation of the ETCS Level 2 system
Source: Author's own materials

The 'High-Speed Railway Development in Poland' Conference – What comes next?

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Abstract: On 28-30 October 2024 in Łódź, during International Scientific and Technical Conference 'High Speed Railway Development in Poland' needs, opportunities and challenges related to the currently being prepared construction, than implementation and subsequent operation of the high-speed rail in Poland were widely discussed. Statements during debates and discussions accompanying multiple presentations were used to formulate conclusions, which were written down and handed over to the decision-makers and stakeholders for use. This article quotes and briefly summarises those conclusions, so that they are available to all interested parties.

Keywords: *High speed railways (HSR); Coherency between HSR and Polish railway system; HSR competence buildingi*

Introduction

On 28 October 2024, four debates took place, focusing on the following topics: 1. 'High-Speed Rail for Poland,' with an opening address delivered by Minister Piotr Malepszak; 2. 'PKP PLK and CPK investments are an opportunity for the development of Łódź and Central Poland,' with an opening address from the CPK company authorities; 3. 'The role of high-speed rail as an element of the TEN-T network in the development of an integrated European railway system,' with an opening address from the PKP PLK company authorities; and 4. 'Complementary Services for the High-Speed Rail system,' with an opening address from the PKP company authorities. Over the following two days, nearly fifty presentations were delivered across seven sessions, offering perspectives from both railway entities and industry stakeholders on topics including: engineering structures, track infrastructure, control systems, safe train operation monitoring, communication, traction power supply, high-speed rail rolling stock and complementary services, as well as legal and organisational challenges. Following the conference, six key conclusions were formulated, documented, and handed over to decision-makers and stakeholders for further use. These conclusions are quoted and briefly discussed below.

Conclusions from the Conference

A broad and comprehensive discussion on the needs, opportunities, and challenges related to the development of high-speed rail (HSR) in Poland highlighted numerous issues requiring particular attention and pointed to necessary complementary actions. Each of the conclusions below is presented as a separate subsection.

Complementary infrastructure projects for HSR

The following conclusion was formulated in this area:
The construction of an HSR line through Łódź, which will carry high passenger volumes, creates an urgent need to launch infrastructure projects on complementary railway networks to accommodate the increased capacity demands for both conventional long-distance and regional rail services in central Poland. These projects should include: (1) Increasing the permitted speed and installing automatic line block signalling on the Łódź – Sieradz section; (2) Upgrading the Zgierz – Kutno line to a double-track railway with a speed limit of up to 160 km/h; (3) Modernising the Łódź Widzew – Tomaszów Mazowiecki – CMK connection for speeds of up to 200 km/h.

Ensuring technical compatibility between HSR solutions and the characteristics of Poland's existing railway network—allowing HSR rolling stock to operate on other currently used railway lines—is the bare minimum. However, experiences from other countries and a holistic view of the railway system indicate that such a minimum is often insufficient for fully leveraging the potential of high-speed rail. Therefore, in parallel with the construction and commissioning of HSR lines, investments in conventional infrastructure should be carried out—eliminating bottlenecks that may not yet be critical but will become obstacles to fully utilising the HSR network's potential in the future. Without identifying and implementing these conventional infrastructure investments, the reduction in travel times will not be accompanied by the necessary increase in capacity and operational flexibility. This, in turn, will become a barrier to meeting the rising demand for rail transport, which will grow as service quality improves and travel times decrease.

HSR rolling stock and complementary transport vehicles

The following conclusion was formulated in this area:
The commencement of HSR line construction creates an urgent need to define both the organisational model and funding principles for rolling stock. It is essential to swiftly determine a comprehensive set of requirements for both high-speed rolling stock and vehicles necessary for complementary transport services. Given the long lead times required for contracting, manufacturing, and delivery, and considering that the rolling stock will undoubtedly be produced to precise, pre-defined specifications, appropriate decisions and actions must be taken without delay.

A holistic approach to transport services utilising high-speed rail lines must not overlook the availability of rolling stock suited to different types of services. Not all trains operating on HSR lines need to utilise the maximum permitted speed in full. This means that now is the time to plan the transport service offer and define the number and specifications of trains required to meet the planned service demand, as new trains are not available off-the-shelf but are produced to order. Considering the time required for tender documentation preparation, procurement procedures in accordance with public procurement law, manufacturing, certification, and final approvals, the target organisational model must be defined immediately. Securing funding and initiating prompt action is critical to ensuring that the necessary rolling stock is available when the infrastructure investment is completed.

Defining and implementing principles for developing HSR competencies in the national industry

The following conclusion was formulated in this area:
The goal of maximising the potential of Polish companies in the construction and operation of high-speed rail (HSR) lines creates an urgent need to define and implement principles that will enable the domestic industry to develop rationally justified solutions for HSR. These principles should ensure that design competencies are expanded and production resources are developed within Poland. This is necessary not only to keep tax revenues and highly skilled jobs within the country but also to facilitate a future technological leap for conventional railway lines and to enable Polish companies to compete internationally, for example, in the construction of a Warsaw – Kyiv railway connection.

Both HSR infrastructure investment and the production of appropriate rolling stock require the advancement of competencies within the local industry, ensuring that at least part of the funding continues to benefit the Polish economy for as long as possible.

The Polish railway system is one of the largest in Europe. It is worth recalling that in 2004, when Poland joined the European Union, its railway network accounted for 50% of the new railway infrastructure added to the EU—meaning that the remaining nine new member states combined had a network roughly equal to Poland's. The scale and volume of railway infrastructure investments in Poland have increased since then, and many local construction contractors carry out these projects. Although railway investment in recent years has been focused almost exclusively on modernising existing lines, Polish contractors have acquired a number of high-performance railway construction machines. Additionally, many of the materials and components used in these projects are produced domestically. However, this does not mean that railway construction contractors and railway infrastructure manufacturers do not need to expand and refine their competencies—they do, and significantly so, because HSR is a completely different level of technology and project complexity. The competition will be at least European-wide, but excluding local businesses from such a major investment at the outset is not an option.

Similarly, in rolling stock production, Poland has several train manufacturers due to the scale of its railway transport sector. The increase in train speeds requires substantial changes in technical solutions, making it necessary to develop new competencies and enhance existing technologies. As in infrastructure, the rolling stock procurement process will attract multiple foreign bidders, but it is critical to ensure that Polish companies are not excluded from the outset.

History has shown that large railway infrastructure projects can transform not only transport networks but also the local economic landscape. The same should happen in this case. However, achieving this requires effective communication between industry and decision-makers regarding expected technical characteristics, development trends (e.g. standardisation of interfaces in control systems), and cybersecurity requirements.

Development of domestic polish solutions for the 2 x 25 kV AC power supply system

The following conclusion was formulated in this area:
One of the challenges will be the development of a domestic 2 x 25 kV AC power supply system. Such a system can be purchased based on European requirements, but Poland has the resources to create national solutions. This requires urgent decisions, including the establishment and launch of a research and development programme, as well as consideration and possible initiation of the procurement of, among other things, dedicated transformers adapted to Poland's national power system.

A particularly significant challenge will be the transition to a new traction power supply system. Currently, no railway lines in Poland use AC power supply, yet this will be essential for high-speed rail. With the existing 3 kV DC system, it is impossible to achieve sufficiently high train speeds. The challenge will not only involve the railway-specific aspects of power supply but also its integration with the national power grid and the expansion of energy generation capacity to ensure adequate power availability. Additionally, interface points between tracks with different traction power systems will pose a further technical challenge.

Unification of technical standards for HSR lines

The following conclusion was formulated in this area:
The commencement of work on tender documents for the construction of the first HSR sections between Warsaw and Łódź, as well as the decision that CPK will transfer completed HSR lines to PKP PLK for operation, highlights an urgent need to establish unified technical standards.

PKP PLK currently applies standards developed in 2009, which have undergone only minor updates in subsequent years and do not reflect the latest requirements of the Technical Specifications for Interoperability (TSI). In contrast, CPK uses standards developed in 2021, which underwent substantial refinements in 2022 and 2023. While CPK's standards cover a significantly broader scope of requirements, they must be updated following changes to nine TSI specifications (Regulation (EU) 1694/2023) and require extensive revisions to safe train control requirements based on the new edition of the TSI specifications for control-command and signalling (Regulation (EU) 1695/2023).

A common set of railway standards should also incorporate detailed, unified requirements for infrastructure design using BIM (Building Information Modelling) technology. BIM facilitates rapid and efficient decision-making during the operational phase after the lines are commissioned. Given the numerous infrastructure interface points, the General Directorate for National Roads and Motorways (GDDKiA) should also adopt BIM standards for road infrastructure design.

During the conference, selected volumes from the 32-volume set of Polish railway standards developed for CPK were presented. Additionally, arguments were made regarding the need to supplement these standards, for example, in the area of digital documentation using BIM. Updates are also necessary in ETCS (European Train Control System) standards following the introduction of ETCS Baseline 4 in European regulations. Furthermore, existing standards do not yet account for the new railway communications system, FRMCS (Future Railway Mobile Communication System). It is also essential to ensure compatibility between the standards used by PKP Polskie Linie Kolejowe S.A., which manages the main national railway network, and those developed for CPK, which apply to high-speed railway line design.

Development of research and testing facilities

The following conclusion was formulated in this area:
It is essential to urgently adopt a plan and proceed with the construction and commissioning of appropriate testing facilities, including: (1) A temporary test site within the first section of the Warsaw–Łódź HSR line, dedicated to testing and certifying railway infrastructure and rolling stock for the launch of initial services on the high-speed line; (2) A permanent, independent testing facility, separate from the HSR network, which could continue to be used after the commencement of high-speed rail operations for the development and validation of various HSR technologies, both current and future. This includes rolling stock, from trainsets to special-purpose vehicles (e.g. diagnostic trains), high-speed rail turnouts, digital systems, ranging from traditional control systems and safe train operation monitoring to automated ATO/ATS systems and cybersecurity protections.

Before HSR infrastructure and rolling stock can be commissioned for operation, they must undergo formal acceptance based on prior testing. However, this is only a temporary research challenge. A much greater challenge lies in establishing a long-term testing facility for refining and approving local technical solutions, both during HSR construction and after its launch. Poland already possesses some relevant infrastructure and expertise, such as the test track near Wrocław, but these are insufficient for high-speed rail. A particular challenge in this area will be the use of AC power supply, though this is only one example. Many new or modified solutions for high-speed infrastructure and rolling stock cannot be safely tested in commercial operations, yet technological advancements will undoubtedly require such testing. Without a dedicated research and testing facility in Poland, the implementation of technological progress will continuously depend on foreign solutions, thereby missing the opportunity for synergies between this major infrastructure project and domestic economic development.

Conclusion

The conclusions from the conference ended with the assertion that:
It is essential to urgently adopt a plan and proceed with the construction and commissioning of appropriate testing facilities, including: (1) A temporary test site within the first section of the Warsaw–Łódź HSR line, dedicated to testing and certifying railway infrastructure and rolling stock for the launch of initial services on the high-speed line; (2) A permanent, independent testing facility, separate from the HSR network, which could continue to be used after the commencement of high-speed rail operations for the development and validation of various HSR technologies, both current and future. This includes rolling stock, from trainsets to special-purpose vehicles (e.g. diagnostic trains), high-speed rail turnouts, digital systems, ranging from traditional control systems and safe train operation monitoring to automated ATO/ATS systems and cybersecurity protections.

There is no doubt that the construction and launch of high-speed rail in Poland should transform railway transport, not only along the HSR corridor itself but also on a much broader, network-wide scale, as well as the economy in the wider construction sector, including the production of building materials, the execution of linear and infrastructure construction works, the manufacturing of equipment, and the performance of installation, repair, and maintenance activities. It should also impact the rolling stock sector in the broadest sense, covering HSR trains, rolling stock for complementary transport services, maintenance and repair work, and rolling stock depots. To make this possible, the conclusions from the HSR Conference in Łódź, as outlined above, should already be taken into account in the planning and implementation of Poland's high-speed rail project. ◀

IT/OT in Rail Transport
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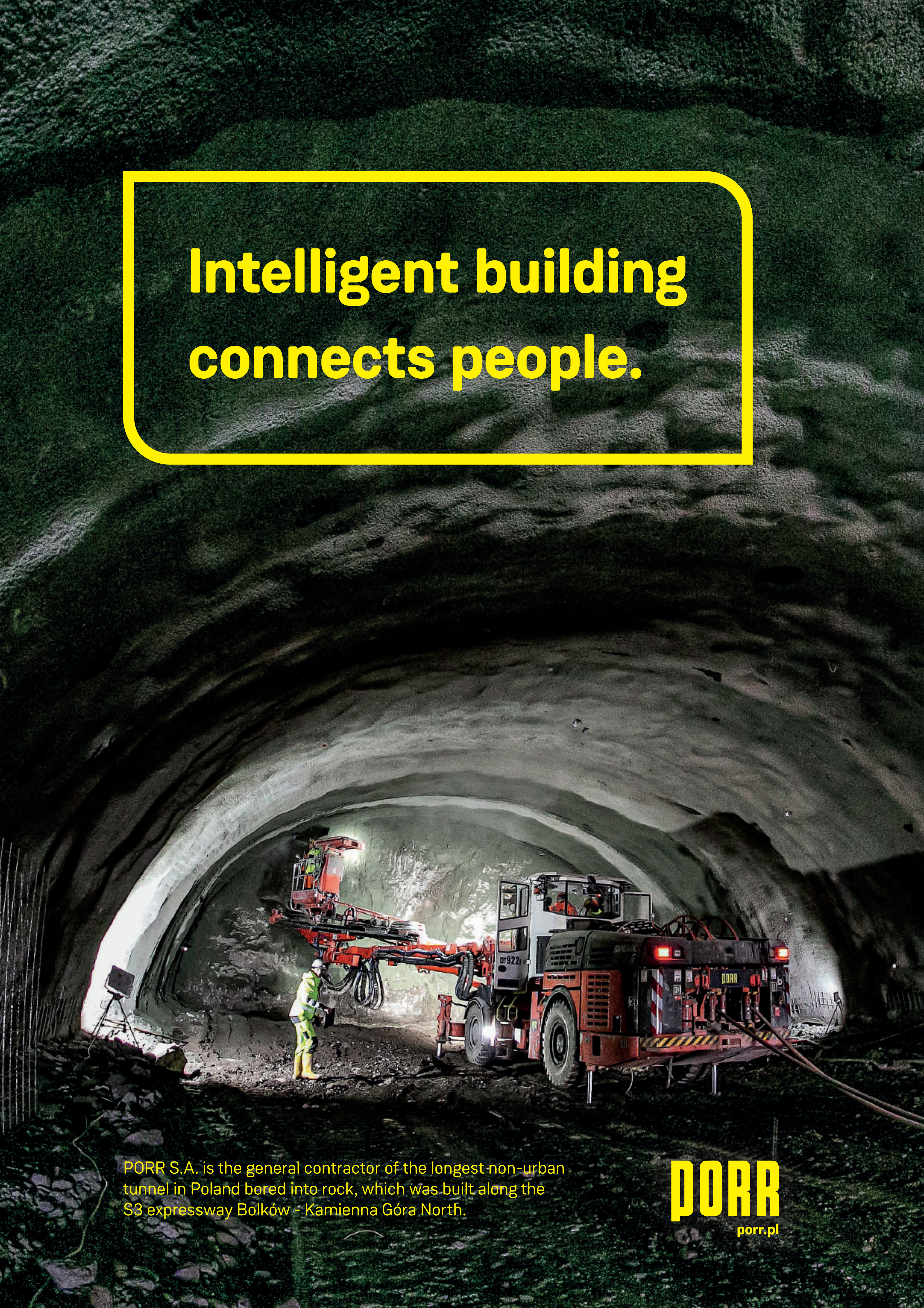
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