The CER Essay series

Where academic analysis meets business insight

Czech high-speed rail for a sustainably connected Europe

by Bc. Jiří Svoboda, Prof. Ing. Ondřej Jiroušek and Assoc. Prof. Otto Plášek

CER
The Voice of European Railways

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

BRNO UNIVERSITY OF TECHNOLOGY

SPRÁVA ŽELEZNIC

CER Essays

The CER Essays initiative features a series of essays that show the rail sector as contributing not only to EU transport policy, but touching on different aspects of society at large. Topics covered by the initiative will range from modal shift, climate policy, infrastructure investment, high-speed rail, demography and more. Each essay will feature a different topic and be co-authored by a CER member CEO and a leading academic from the same country and will be used to spark debate among political stakeholders on the role of rail in the EU.

Follow the whole series

Contents

About the authors

Bc. Jiří Svoboda, MBA

After gaining sound operational experience as a dispatcher at the national rail carrier České dráhy, Jiří Svoboda worked from 1997 as a Technical Group Lead at the Česká Třebová railway station, then as Technical & Economic Deputy Chief, and eventually as Deputy Director for Economics at the Directorate for Rail Commerce and Operation in Pardubice. From 2006 he served as the Director of the Office of the Director General at České dráhy and later at Správa železniční dopravní cesty. From 2011 he led the Purchase and Public Procurement Department of Správa železnic, serving as the Deputy Director General for Rail Operability from 2016 to 2018, when he accepted the position of Director General of Správa železnic.

Prof. Ing. Ondřej Jiroušek, Ph.D.

Ondřej Jiroušek is among the leading Czech experts in the field of material analysis and failure diagnostics with a focus on railway structures. After postgraduate studies at the Faculty of Civil Engineering of the Czech Technical University in Prague (CTU) in 1999 he worked at the Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences where he later headed the Department of Biomechanics.

Currently he serves as the Head of Department of Mechanics and Materials at the CTU Faculty of Transportation Sciences and chairs the Scientific Counsel of the Czech Technology Platform "Interoperability of Railway Infrastructure". His research focuses on diagnostics, numerical analysis and modelling of deformable bodies, and he has participated in projects funded by the Czech Technology Agency (TACR), as well as EU projects such as INNOTRACK and STAFFER.

Assoc. prof. Otto Plášek, M.Sc., Ph.D. (M)

Otto Plášek is known as one of the leading Czech experts specialised in analysis and diagnostics of railway superstructure dynamic behaviour. With a deep professional background as a railway engineer he moved in 1991 to the academic field becoming a lecturer at the Brno University of Technology (BUT), Faculty of Civil Engineering. Since 2010 he has been leading the Institute of Railway Structures and Constructions, and in 2012 he also became a senior researcher at the Centre for Advanced Material and Structures.

He has served in a number of respected positions such as First Vice-Chair of the Managing Board of the Czech Technology Platform "Interoperability of Railway Infrastructure"). In the last two decades his R&D activities focused on the static and dynamic analyses of railway superstructure and its components (e.g. rail fatigue, sleepers, switches and crossings design) as well as on on-site measurements of switch actuating systems, deflection and vibration of track superstructure, track and bridge interaction and failure diagnostics.

Foreword

"If the Central European region wants to remain an integral part of an interconnected Europe, we need to keep pace with the constantly evolving trends. Správa železnic is a modern organisation and responsible infrastructure manager with a high level of expertise and experience, and makes every effort to meet this objective.

Hereby, let me thank all of my fellow railway colleagues in Czechia and abroad, the professional public, experts from governmental authorities, the European Commission and other EU institutions and platforms for support and help in realising the vision of high-speed rail network development in Central Europe.

My dream is that thanks to high-speed trains we will once again grow a little closer to each other in Europe, not only in terms of distance but also as human beings."

Bc. Jiří Svoboda, MBA

Director General
Správa železnic, státní organizace

My dream is that thanks to high-speed trains we will once again grow a little closer to each other in Europe, not only in terms of distance but also as human beings.

Executive Summary

This essay explores the contribution of High-Speed Rail ("HSR") to the fulfilment of Europe's transport development concept, particularly in Central Europe.

The introductory chapter presents the strategic EU documents and analyses the role of rail transport and HSR development in the EU.

The part devoted to the Czech Republic ("Czechia") focuses mainly on the concept background and characteristics of technical design of individual HSR lines at different stages of progress.

Using concrete examples, the economic benefits chapter presents the long-term demographic, environmental and transport gains generated by HSR in Czechia.

The science and research section further describes the strategic European and national background and possible course for HSR research.

The final section on education and training outlines the rail staffing challenges and considers ways to address them.

Introduction

Alberto Mazzola

CER Executive Director

This essay shows one of the outstanding infrastructure projects of Europe that will be part of the European High Speed Network and TEN-T.

With the EU Smart and Sustainable Mobility Strategy's (SSMS) ambitious targets for rail, there is an urgency for the sector to deliver the Single European Rail Area and make modal shift a reality in order to reach a 90% reduction in transport emissions by 2050. One of the tools to ensure that rail delivers as the most sustainable transport mode is the Trans-European Transport Network (TEN-T) policy. As part of the Green and Efficient Mobility Package, the European Commission published its Proposal for a TEN-T Regulation helping to achieve the objectives set out in the European Green Deal and SSMS by greening transport, facilitating a seamless, efficient and interoperable mobility system, strengthening the resilience of infrastructure and boosting economic, social and territorial cohesion between all Member States and their regions, as well as beyond the EU.

A most prominent part of TEN-T policy must be devoted to the European High-Speed Network. The SSMS sets ambitious targets in this area: doubling high-speed rail traffic by 2030 and tripling it by 2050. The creation of a European high-speed network that is interoperable, linking European capitals and major cities, connecting urban nodes and airports and supporting the development of international passenger services is key to ensure the modal shift to rail.

High-speed rail can compete with air travel up to 800-1,000 kilometres, presenting a sustainable and comfortable alternative to passengers, being easier to use and 15 times more energy efficient. A lot has been achieved so far with national success stories including Paris-Lyon, Milan-Rome, Barcelona-Madrid, and Berlin-Munich. However, the current network is mainly made up of "national high-speed islands" and there is a growing need to develop the EU High-Speed Network with a larger number of origin-destinations connecting all EU capitals and major cities.

This essay, authored by Správa železnic, státní organizace (SZCZ) CEO Bc. Jiří Svoboda, Prof. Ing. Ondřej Jiroušek (CTU Praha, Faculty of Transportation Sciences) and Assoc. Prof. Otto Plášek (BUT, Faculty of Civil Engineering) shows one of the outstanding infrastructure projects of Europe that will be part of the European High-Speed Network and TEN-T. The positive cost-benefit analysis of the Czech connections are one of the examples of many other pairs of origin-destination in Europe. As a crucial part of Central Europe's high-speed railway system, the initiative will significantly improve the connections between Czech regions and neighbouring countries and boost capacity for regional and sub-urban trains on the conventional network. Freight services will also benefit from the construction of these high-speed lines with more capacity to move goods by freight. Similarly, the socio-economic benefits are immense: more than half of the population of Czechia will be within 20 minutes from the high-speed network. That will have a significant, positive impact on regions, employment and the overall economy.

With this high-speed infrastructure project as an example and a network vision of European High Speed, other Member States can follow suit and take up the challenging role of realising a closer, more interconnected Europe with rail as the common denominator and the backbone of sustainable mobility.

High-speed rail as a tool to meet EU objectives in the region

One of the main objectives of European integration is the long-term sustainable economic growth of the community and its competitiveness with other major world economies. A prerequisite to this is a safe, high-quality, integrated, sufficiently permeable, universally accessible and sustainable transport infrastructure that is energy efficient and fossil fuels independent.

The guiding principles for the development of the single European transport area by 2050 are set out in the *White Paper – Roadmap to a single European transport area – Towards a competitive and resource-efficient transport system* ("White Paper"), which emphasises a modal shift towards rail as a low-emission transport mode. It also sets a strong focus on expanding the interconnected high-speed rail (HSR) network that has the potential to replace shorter-distance air transport within the EU. The EU Sustainable and Smart Mobility Strategy in its latest version further elaborates the objectives set out in the White Paper transport policy.

Furthermore, the *European Green Deal* addresses the long-term sustainable and environmentally friendly mobility development with an emphasis on responsible handling of natural resources in terms of:

1. the shift towards a clean economy (circular economy, carbon neutrality),
2. maintaining biodiversity and pollution reduction.

The Trans-European Transport Network ("TEN-T") policy defines railway backbone corridors, thus providing the necessary transport infrastructure for proper functioning of the single market and achieving the long-term strategic objectives of the EU. The means to realise this is smart, sustainable and environmentally friendly mobility.

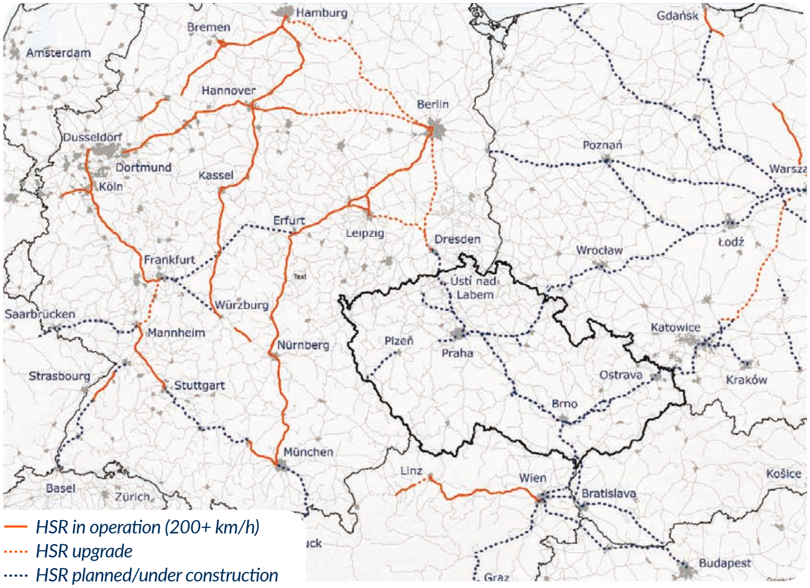
The establishment of a high-quality HSR system (Fig. 1) is an integral part of such a policy. Passenger transport makes a significant contribution to regional development by improving transport services in the area. The resulting demographic effect is particularly noticeable in the densely populated Central Europe region.

Europe's shift from carbon-intensive industry to cleaner technologies is also having a significant impact on the composition and volume of freight flows where high-capacity and reliable European Rail Freight Corridors ("RFC") are as crucial as ever. In the context of the Central European Region, we speak of the Baltic-Adriatic, Orient/East-Med, North Sea-Baltic and Rhine-Danube RFCs.

The indisputable advantages of rail over other transport modes are as follows:

1. transport capacity : high-capacity transport capable of covering long distances,
2. energy consumption : extremely low per tonne of cargo or per passenger,
3. emissions : extremely low emission footprint in case of electric traction,
4. permanent noise pollution : significantly better parameters than road transport,
5. infrastructure spatial requirements : significantly lower space demand (per transported volume) than road transport,
6. travel comfort : able to provide a very high standard,
7. travel time : on shorter distances, HSR can successfully compete with air transport.

FIG. 1: HSR IN OPERATION OR PLANNED IN CENTRAL EUROPE (STATUS SPRING 2021)



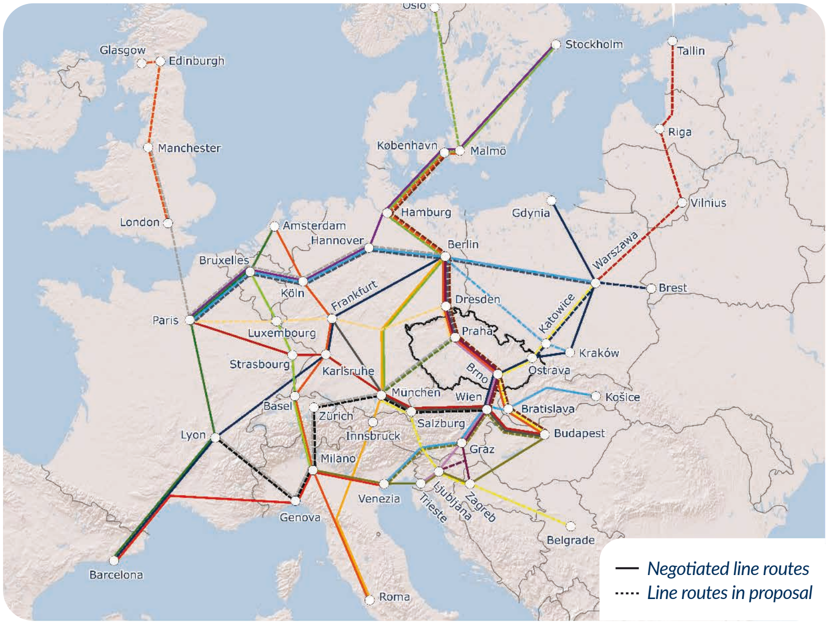
Even greater rail transport efficiency and performance can be achieved through:

1. increased speed (HSR network),
2. existing connections optimisation, linkage to other transport modes (TEN-T, RFC network, Trans Europe Express (TEE) 2.0[1] and EUROLINK initiatives),
3. technical, administrative and procedural harmonisation (standardisation, interoperability and safety – TTR project[2], TSI[3]),
4. network management components and technology upgrades (digitalisation, predictive maintenance, ERTMS),
5. consistent application of R&D results, especially of the Europe's Rail Joint Undertaking[4] projects (high-capacity trains, increased availability and reliability of infrastructure).

1 *Trans Europe Express 2.0 is a successor to Trans Europe Express services operated from the 1950's to the 1990's*
2 *Timetabling and Capacity Redesign, formerly TTR for Smart Capacity Management*
3 *Technical Specifications for Interoperability*
4 *The successor to the Shift2Rail Joint Undertaking*

A good example of the current trend in rail integration is the TEE 2.0, which aims at reviving the idea of long-distance day and night connections. This idea is accelerated by the *"Via Vindobona"* agreement from May 2021 between Germany, Czechia and Austria, declaring a framework for intensive passenger rail connections between the national capitals with the prospect of achieving a four-hour journey time on the Berlin – Praha – Wien route. The proposal is linked to the Deutschland Takt project. *Fig. 2* shows the proposed TEE 2.0 network diagram.

FIG. 2: PROPOSED TEE 2.0 LINES (STATUS SPRING 2021)



©2014 Esri

Czech HSR is key to region's wider integration

Efforts to increase performance of the existing rail network on a pan-European scale hit infrastructure capacity problems. Czechia is no exception. Although the upgrade efforts on the so-called transit railway corridors since the 1990s yielded the expected capacity increases, concurrently they triggered additional and significant transport demand. The congested backbone network with its significant limitations for the further increase of technical parameters is no longer sufficient, and a new HSR system that will meet the requirements of the 21st century is therefore necessary. HSR will significantly improve the regions' otherwise unattainable interconnectivity, it will provide more attractive cross-border journey times between the main international hubs in Czechia, Germany, Austria, Poland and Slovakia, and, through segregation of long-distance passenger transport, it will help to relieve the conventional network bottlenecks and free up their capacity for international freight transport.

In the national context, the concept of HSR network design is anchored in the following documents:

- *Transport Policy of the Czech Republic for the period 2014 – 2020 with a prospect until 2050* ("The Czech Transport Policy"), updated for the period of 2021–2027
- *Policy of Territorial Development of the Czech Republic*, defining the main HSR corridors connecting with similar foreign corridors.
- *Programme of the Development of Rapid Railway Connections in the Czech Republic*[5] ("RC programme") issued by the Ministry of Transport of the Czech Republic ("Czech MoT").
- *Transport Sector Strategy* (Czech MoT, update 2017) elaborating the individual infrastructure plans.

5 The understanding of the Rapid Connections (RC) concept is broader than the concept of High-Speed Rail (HSR). While HSR envisages operating speeds of 200–320 km/h, RC also includes upgraded lines with speeds of up to 200 km/h.

From the strategic point of view, the overall concept follows the objectives of the TEN-T policy and the EU White Paper, where in particular the Berlin – Praha – Wien/Bratislava and Bratislava/Wien – Ostrava – Katowice/Warszawa routes play a key part in the entire HSR system of the Central European region.

Over the last two years, thanks to cooperation with SNCF and political support from the EU and neighbouring countries, Správa železnic has made significant progress in the HSR design preparation. In order to maintain the momentum, and since the current Connecting Europe Facility (CEF) programme concentrates exclusively on co-financing of TEN-T Core Network projects, it is crucial that all proposed HSR connections in Czechia are included in the TEN-T Core Network (*Fig. 3*). Therefore, the ambition of Správa železnic and the member state Czech Republic is to include the entire planned Czech HSR system in the TEN-T Core Network under the latest TEN-T revision (*Fig. 4*).

From an international perspective, Czechia lies at the crossroads of two basic directions (Tab. 1):

- West – East, (Berlin) – Praha – Brno – Břeclav – (Wien/Bratislava/Budapest),
- South – North, (Budapest – Bratislava/Wien) – Brno – Ostrava – (Katowice – Warszawa/Kraków).

TABLE 1: DEVELOPMENT OF TRAVEL TIMES BETWEEN MAJOR HUBS

Line	Now	2030	2040	Trend
Berlin - Wien	8h	6h	4h	↘ -4 h
Berlin - Praha	4h	3h	2h	↘ -2 h
Praha - Wien	4h	3h	2h	↘ -2 h
Praha - Brno	3h	<2h	1h	↘ -2 h

FIG. 3: TEN-T NETWORK IN CZECHIA AS OF 2021

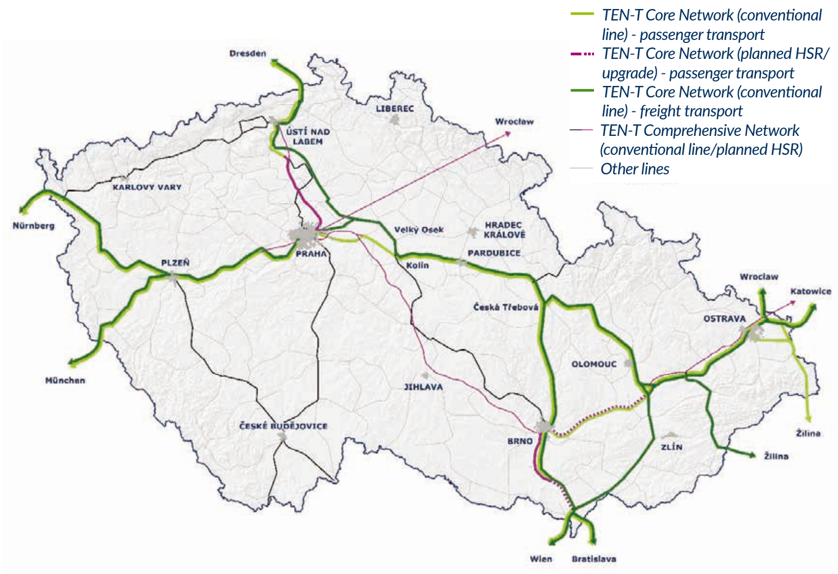
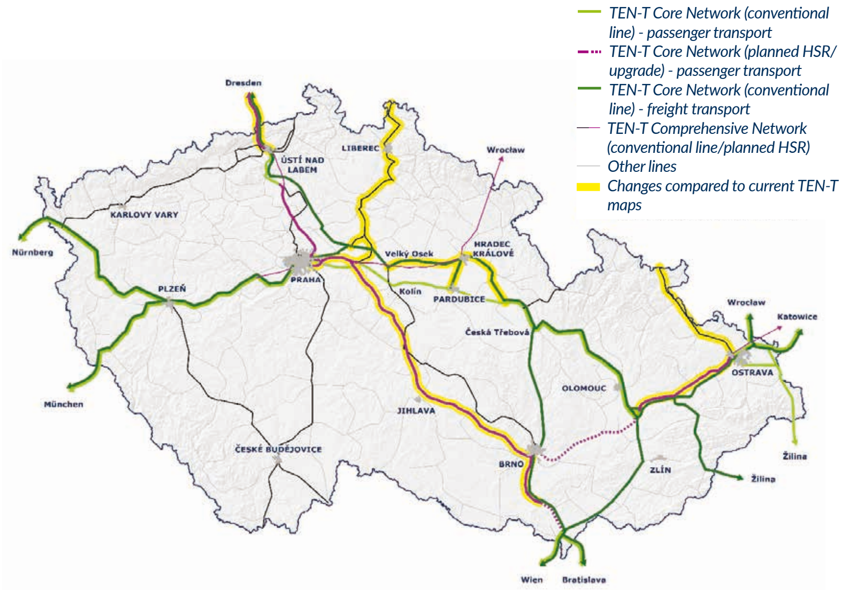


FIG. 4: TEN-T NETWORK IN CZECHIA – REVISION PROPOSAL



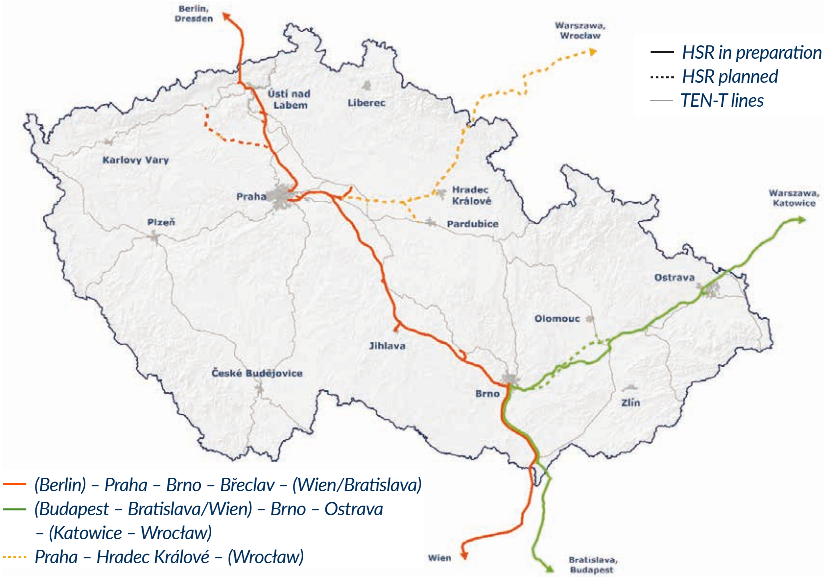
Similarly, the RC Programme includes three HSR backbone corridors that follow these directions:

- (Berlin) – Praha – Brno – Břeclav – (Wien/Bratislava/Budapest),
- (Budapest – Bratislava/Wien) – Brno – Ostrava – (Katowice – Warszawa/Kraków),
- Praha – Hradec Králové/Pardubice – (Wrocław).

The German connection represents an indispensable link between Czechia and the Western European HSR network. The direction to Wien will provide a connection to the Austrian HSR system and to the South of Europe region, while the connection to Bratislava and Budapest will provide a connection to the East and the Balkans. The Polish connection will enable a direct link between Praha, Warszawa and an interconnection to the Polish HSR network (with extension to the important Rail Baltica project in the Baltics).

The upgrade schedule of the national TEN-T network, including commissioning of HSR structures divides into Phase I (Core Network) by 2030 and Phase II (Comprehensive Network) by 2040. Due to the complexity of all the processes, the design of all these HSR lines is already in progress. The expected commissioning of the first HSR section on the Praha – Brno line is set for 2028. Furthermore, modernisation of the railway junctions in Praha, Brno and Ostrava is also closely coordinated. The *Fig. 5* shows the diagram of design preparation, construction and commissioning processes.

FIG. 6: HSR PREPARATION IN CZECHIA (STATUS SPRING 2021)

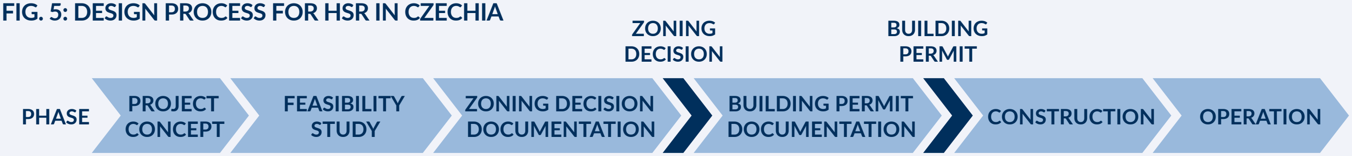


Axis (Berlin) – Praha – Brno – Břeclav – (Wien/Bratislava)

Internationally, this key line provides a fast connection between Berlin, Praha, Wien, Bratislava and Budapest. Nationally, this axis represents the backbone of the Czech system connecting the two largest Czech cities Praha and Brno. Moreover, linking the regional capital Jihlava will significantly improve the transport services of the Vysočina Region. This HSR line consists of sections (*Fig. 6*, in red):

- German/Czech border– Ústí nad Labem – Praha,
- Praha – Brno,
- Brno – Břeclav – Czech/Austrian/Slovak border.

FIG. 5: DESIGN PROCESS FOR HSR IN CZECHIA



HSR section State border DE/CZ – Ústí nad Labem – Praha

This is technically a very complex section with two extremely long tunnels planned. The cross-border Krušnohorský (Ore Mountains) Tunnel (minimum length 26 km) presents a particular challenge where preparation and construction must be anchored at the political (governmental) level and technically in harmonised procedures between DB Netz and Správa železnic.

This section will help to satisfy passenger and freight segment transport demand on this route while significantly reducing travel time. Similarly, all of the North-West Bohemia region (structurally the most affected in Czechia) will benefit from improved rail connections. An important factor is also relieving the Elbe River valley of the environmental burden. Prospectively, the travel time between Praha and Ústí nad Labem will be cut from today's one hour and 15 minutes down to 30 minutes. The estimated Praha – Dresden travel time will drop to less than 60 minutes.

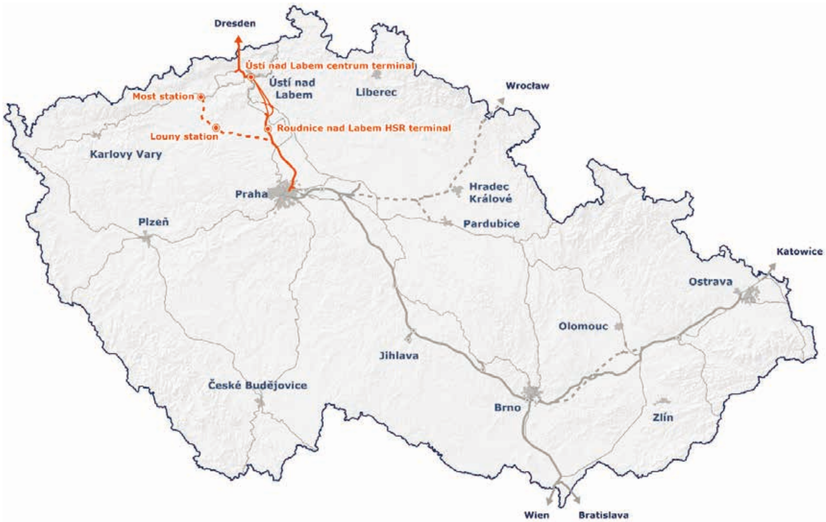
Additionally, the potential important connection to the city of Most and the famous spa city of Karlovy Vary will yield further benefits.

In terms of technology and operation, this route splits into sub-sections (*Fig. 7*) which can be commissioned independently, with immediate benefits for the entire route.

Unlike the other sub-sections operating mixed traffic, the sub-section Praha – Litoměřice Exit will serve exclusively passenger transport with maximum operating speed 320 km/h (prospectively even 350 km/h). The design speed in the Středohorský (Central Bohemian Highlands) Tunnel is 250 km/h and in the Krušnohorský Tunnel 200 km/h (subject to further analyses, up to 230 km/h).

At the end of 2020 the Feasibility Study (FS) for the HSR section Praha – Ústí nad Labem (– Dresden) was approved by the Central Commission of the Czech Ministry of Transport. Thus, the preparation entered the zoning decision documentation and the Environmental Impact Assessment (EIA) phases. The construction of the first 58 km sub-section is planned to begin in 2027.

FIG. 7: HSR (DRESDEN) – ÚSTÍ NAD LABEM – PRAHA



HSR section Praha – Brno

This section (*Fig. 8*) has a completely new route and considers exclusive passenger transport up to a speed of 320 km/h. Technically, the route splits into several sub-sections among which the Praha – Poříčany sub-section design preparation progress is the most advanced – the construction is expected to start in 2026. On this sub-section, an important terminal, Praha Východ (*Fig. 9*), will serve the North-Eastern part of the Central Bohemian Region, offering fast commuting to the centre of Praha and direct long-distance connections to Brno (Ostrava, Wien), Hradec Králové (Wrocław) and Dresden. The sub-sections Poříčany – Světlá nad Sázavou and Velká Bíteš – Brno are expected

FIG. 8: HSR (BERLIN) – PRAHA – BRNO – BŘECLAV – (WIEN/BRATISLAVA) AND BRNO – OSTRAVA – (KATOWICE/WARSZAWA)

to see construction start in 2027. The construction of the middle sub-section Světlá nad Sázavou – Velká Bíteš should commence in 2029.

Depending on the train category, the projected travel time will drop from the current two hours and 30 minutes to around one hour.

The related FS was completed in spring 2021 and the phase of zoning decision documentation and EIA is in progress.

HSR section Brno – Břeclav – State border CZ/AT/SK

This HSR section also serves the South-North direction. An exclusive passenger transport is expected here. The sub-section Brno – Šakvice uses a completely new route enabling an operating speed of 320 km/h. The construction is planned to start in 2027. The sub-section Šakvice – Břeclav – Czech/Austrian/Slovak border should see an upgrade of the existing route for a speed of 200 km/h.

FIG. 9: VISUALISATION OF PRAHA VÝCHOD TERMINAL

Although this relatively short section will reduce travel time by just around 15 minutes, its main contribution is the foreseen benefit for international connections.

The related FS was completed in the spring of 2021 and the preparation continues with the zoning decision documentation and EIA phase.

Axis (Budapest – Bratislava/Wien) – Brno – Ostrava – (Katowice – Warszawa)

From the European perspective, this axis connects the hubs of Budapest, Bratislava and Wien, with Warszawa and Kraków. Regarding the infrastructure, this axis consists of the following HSR sections (*Fig. 5*, in green):

- Czech/Austrian/Slovak border – Břeclav – Brno,
- Brno – Ostrava – state border CZ/PL.

HSR section State border SK/AT/CZ – Břeclav – Brno

This HSR section also serves the West-East direction as described in the paragraph "HSR section Brno – Břeclav – State border CZ/AT/SK".

HSR section Brno – Ostrava – State border CZ/PL

This connection links Brno and Ostrava, respectively the second and third largest cities in Czechia, as well as the regional capital Olomouc. Technically, it consists of two sub-sections:

- Brno – Přerov in the first phase routed over the existing modernised tracks with speeds up to 200 km/h,
- Přerov – Ostrava in a new route with an operating speed of 320 km/h.

The start of construction for both sub-sections is expected in 2025. In a next phase, the Brno – Přerov sub-section foresees a new route construction with speeds up to 350 km/h. Exclusively passenger transport is expected here.

The travel time between Brno and Ostrava will thus approach 75 minutes (potentially only 45 minutes in the longer term).

Further mixed operation linkage to the Polish network via Bohumín depends on the design progress of the Polish HSR line to Katowice (the FS works have just commenced). The target travel time for Brno – Katowice could then reach two hours.

Axis Praha – Hradec Králové/Pardubice – (Wrocław)

This represents the future main international route to Poland (*Fig. 10*) providing the fastest connection between Praha, Wrocław, Warszawa and the popular destinations on the Polish Baltic coast (Gdańsk, Gdynia and Sopot). Except the cross-border sub-section, an exclusive passenger transport is planned here. Once in operation, travel time from Praha to Wrocław could be 90 minutes and 3 hours to Warszawa. Domestically, this HSR line will provide a fast connection between Praha and the regional capitals in eastern Czechia, reducing travel times to around 30 minutes.

The connecting branch to Pardubice will enable a transfer of long-distance traffic from the existing railway corridor to the HSR network. This will help to accelerate not only the conventional connections between Olomouc, Česká Třebová and Praha, but will also release capacity for freight transport on the lines through Kolín and Velký Osek (*Fig. 3*).

Technically, this route consists of several sub-sections that can be implemented at different stages gradually improving the connections in this direction. The first sub-section Praha – Poříčany is shared with the HSR route Praha – Brno. The further sub-section consists of a possible extension to Hradec Králové and a branch to Pardubice, at least partly using the existing modernised railway tracks. The last part from Hradec Králové to the Polish border will help to achieve the desired international connection travel times. The currently elaborated FS (due in 2022) will provide the exact parameters and configuration of this HSR line.

FIG. 10: HSR PRAHA – HRADEC KRÁLOVÉ – (WROCŁAW)

Economic benefits of HSR

Although the construction of a HSR system undoubtedly has significant economic benefits from a long-term perspective, in the short-term such investment represents a considerable burden to the national budget. It is therefore crucial that various financial instruments, including EU funds, European Investment Bank (EIB) loans and even Public-Private Partnerships (PPP) are used. The following paragraphs focus on the demographic-sociological, environmental and transport aspects of HSR benefits.

Demographic-sociological aspects

The economic progress of a country directly correlates with mobility of goods and its workforce. The construction of a HSR network will boost regional transport and free up capacity on existing, especially suburban sections of backbone lines. Such an overall improvement of the transport offer will increase the attractiveness of regions, helping to balance regional disparities.

The investment in HSR is expected to open significant business opportunities and stimulate economic growth in the regions. Companies in the proximity of HSR terminals will gain a significant competitive edge while saving on the need to invest in their own transport infrastructure. Local governments can incentivise this by setting attractive business and construction conditions in the given locations, especially through area development and zone regulation plans. Similarly, increased housing demand around new stations will stimulate further housing and social development. The increase of the daily commuting range to over 100 km will reduce unemployment and stop depopulation of rural areas.

Table 2 presents the key economic indicators, which quantify the specific benefits for each HSR line:

TABLE 2: BASIC ECONOMIC INDICATORS PER HSR LINE:

HSR line (direction)	Predominant mode of traffic	Project phases	ERR[6] (%)	ENPV[7] (in thousand CZK)	B/C[8]
(Dresden) – Ústí nad Labem – Praha	passenger/ combined	zoning permit + EIA	6.71	24,943,566	1.31
Praha – Brno – Břeclav – (Wien/Bratislava)	passenger	zoning permit + EIA	7.71	77,234,632	1.47
Brno – Prerov – Ostrava – (Katowice)	passenger	zoning permit + EIA	12.18	102,541,497	2.90
Praha – Hradec Králové /Pardubice – (Wrocław)	passenger	feasibility study	N/A	N/A	N/A

Electric traction in railways has more potential to achieve carbon neutrality and sustainability than other transport means (e.g. electric vehicles).

According to traffic models, the HSR line Praha – Brno will attract up to 60,000 passengers per day. Some 4,000 jobs are expected to emerge around the HSR stations, especially in Jihlava and in the vicinity of Nehvizdy. Furthermore, due to increased housing demand, up to 1,600 new apartments will need to be built in Jihlava alone. The housing development and the influx of residents will trigger further infrastructure investments and expand the local offer in the area of retail, services and leisure. Simultaneously, Jihlava will be potentially able to host significantly more important cultural and social events of national importance than today, and will generally make the Vysočina Region more attractive as a tourist destination.

Environmental aspects

The importance of energy efficiency and lower carbon emissions as a competitive advantage will constantly grow. In this respect, electric traction in railways has more potential to achieve carbon neutrality and sustainability than other transport means (e.g. electric vehicles). However, a prerequisite to this is a sufficient volume of passengers, reliability and attractiveness of the service.

The analysis of the Praha – Dresden HSR line gives a good insight. According to the current Czech energy mix, the calculated HSR transport volume of the CO_2 emissions per train-km[9] is 12,985 g (speed less than 320 km/h), and 9,275 g (speed less than 250 km/h). The financial equivalent of time-spent-on-transport savings over 30 years of operation amounts to 73.5 billion CZK (€ 2.83 billion) and the estimated financial equivalent of corresponding CO_2 savings amounts to 13.7 billion CZK (€ 527 million)[10].

Transport aspects

Considering door-to-door travel, HSR has the potential to be more attractive than air transport for distances of up to 800 kilometres, especially due to a significantly faster "check-in". The economic and social benefits of the agglomeration phenomenon[11] can be achieved exclusively by minimising door-to-door travel times (less than 60 minutes).

6 *Economic Rate of Return – a percentage indicator describing the return on an investment over the period considered (30 years), taking into account various risk factors*
7 *Economic Net Present Value – an indicator expressing the financial return on an investment in money over the period considered (30 years)*
8 *Benefits / Costs – ratio of benefits vs costs*
9 *train-km = train-kilometre, a unit of measurement representing the movement of a passenger train along a distance of one kilometre*
10 *Assumed average exchange rate of € 1=26.00 CZK.*
11 *interconnection of neighbouring cities*

The convenient transfer to urban and suburban public transport (including rail), reflecting the demand and demographic structure of the population plays an important role. The determining factors are the right location of major transport nodes, linkage to other transport modes and good access to city centres. Involvement of the city management in this concept is crucial, heeding two main factors:

- maximising the efficiency and potential of the location for transfer to public transport systems, and easy and quick access for as many residents as possible,
- ensuring the best city development quality within a 10 minutes walking distance (400 to 500 m) from the arrival point of intercity trains.

Rural transfer stations should be designed to encourage passengers to take trains, i.e. they should provide sufficient parking and necessary infrastructure (e.g. electric vehicle charging stations).

The following figures show the "shrinkage" effect on Czechia based on the main centres' transport accessibility development analysis before (*Fig. 11*) and after (*Fig. 12*) the implementation of HSR.

The key criteria for provision of transport capacity on the HSR backbone network with transfers to high-frequency suburban connections are:

- train speed increase, i.e. travel time reduction (*Fig. 13*),
- train frequency increase.

The proportion of waiting time for connections in nodes to the travel time itself is the key parameter here. Growth of this parameter negatively affects the competitiveness of rail against road transport in particular. On lines with travel times of 60 to 90 minutes, a basic interval of 30 minutes is necessary. For connections with travel times longer than two hours, an hourly interval may be sufficient. This is applicable especially for cross-border journeys with lower passenger volumes. Then, such an hourly frequency can be interspaced in 30-minute intervals by connections to adjacent towns with one-hour travel time.

FIG. 11: TRANSPORT ACCESSIBILITY BEFORE HSR IMPLEMENTATION

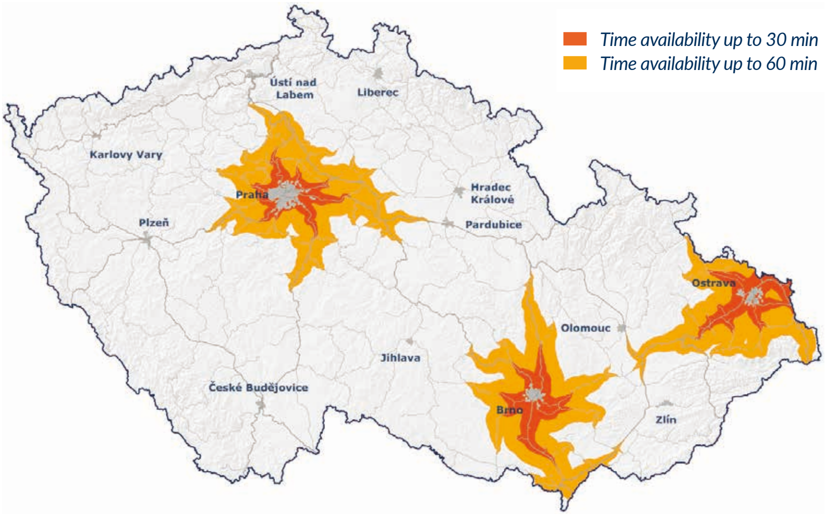


FIG. 12: ANTICIPATED TRANSPORT ACCESSIBILITY AFTER HSR IMPLEMENTATION

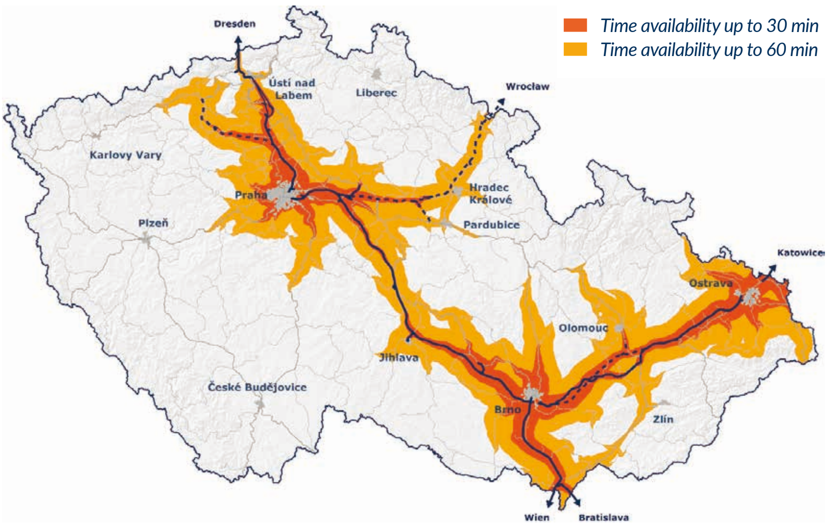
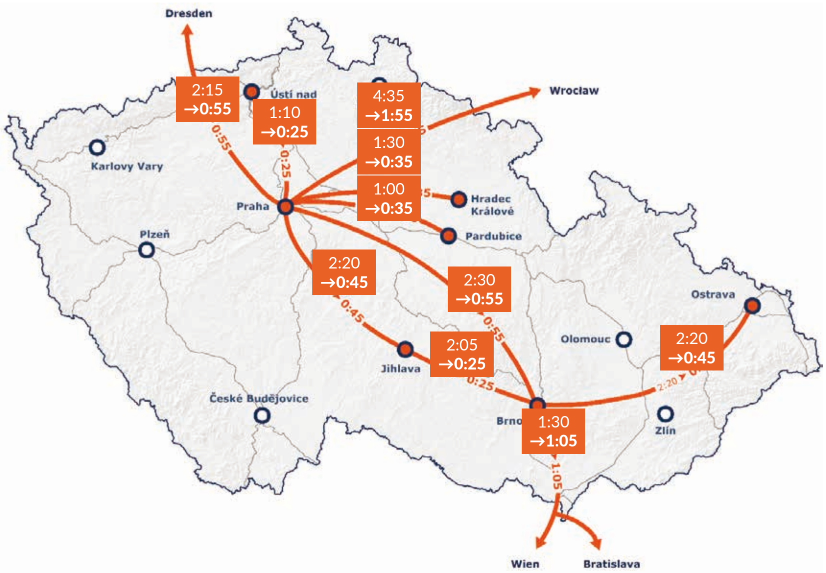


FIG. 13: REDUCTION OF TRAVEL TIMES FOLLOWING HSR IMPLEMENTATION



According to the forecasts, the planned HSR network in Czechia will span approxomately 660 km, carrying over 130,000 passengers daily. Moreover, 5.5 million inhabitants (52.3 % of the Czech population) will be able to reach an HSR station in less than 20 minutes by car thanks to the modern French concept of areal regional train services coming off the HSR network onto the conventional lines. For example, on the Praha – Dresden HSR line alone, the daily travel time saving[12] will total 9,138 hours (horizon 2050). This represents a daily saving of more than half a million kilometres[13] by bus, i.e. a daily reduction of roughly 48 full buses on this route. The economic and environmental benefits are obvious.

Table 3 presents the overall assumption of a transport modal shift towards rail. It shows the current split of passengers per transport mode and the projected passenger demand shift from road to rail after HSR implementation.

TABLE 3: TRANSPORT DEMAND MODAL SHIFT AFTER HSR LAUNCH ON SELECTED ROUTES

Route	Current	HSR operation	Trend
(Dresden) - Ústí nad Labem	37% 7% 56 %	69% 1% 30%	↗ +32% ↘ -6 % ↘ -26 %
Ústí nad Labem - Praha	29% 4% 67%	58% 0% 42%	↗ +29% ↘ -4 % ↘ -25%
Praha - Brno	32% 8% 60%	62% 1% 37%	↗ +30% ↘ -7% ↘ -23%
Brno - Břeclav - (Wien)	38% 5% 57%	46% 2% 52%	↗ +8% ↘ -3% ↘ -5%
Brno - Ostrava	11% 15% 74%	50% 1% 49%	↗ +39% ↘ -14% ↘ -25%

The planned HSR network in Czechia will **span approxomately**

660

km, carrying over 130,000 passengers daily.

5.5 million inhabitants (52.3 % of the Czech population) will reach a HSR station in less than 20 minutes by car.

12 average daily travel time saved by an individual passenger multiplied by the number of passengers
13 average daily travel distance saved by an individual passenger multiplied by the number of passengers

Science and research

Research and development in rail transport

The introduction of new technologies and procedures in the preparation and implementation of HSR in Czechia is based on the requirements and recommendations of the following international key strategic documents:

- *Strategic Rail Research and Innovation Agenda* issued by the European Railway Research Advisory Council (ERRAC), which defines nine major transformation projects,
- New 2021 – 2027 period strategic plan for the Europe's Rail Joint Undertaking,

On the national level further key strategic documents apply:

- *National Strategy RIS3*
- *National Investment Plan of the Czech Republic until 2050*
- *Innovation Strategy of the Czech Republic 2019-2030*

The strategic research and development objectives for high-speed infrastructure pursue the following key directions:

- capacity increase of the railway traffic routes with regards to a modal shift towards rail, in particular by deploying modern technologies,
- reduction of the scale of infrastructure through its use optimisation.

The basic vision is, among others, smart, self-diagnosing and self-learning infrastructure. In the field of smart diagnostics, it means digitalisation and autonomous monitoring systems in particular. These will help to optimise the use of materials throughout the entire life cycle, including final recycling, and to identify the scope of needed maintenance at the right spot and the right time (predictive maintenance). This aims at minimising the operation outages and at increasing the reliability of the railway transport route both for passenger and freight railway undertakings ("RUs").

There are severeal essential topics for the introduction of the latest findings and technologies in the comprehensive development of HSR:

- development of structures and materials to increase infrastructure resilience (e.g. use of nanotechnologies), use of highly specialised machinery equipment, introduction of modular solutions for easy and quick replacement of worn or obsolete infrastructure components,
- digitalisation and development of tools modelling the entire life cycle of assets (Building Information Modelling – BIM, digital twins),
- non-invasive, non-destructive and autonomous diagnostics and infrastructure monitoring,
- predictive maintenance of railway infrastructure that minimises operational restrictions, better insight into the technical deterioration mechanisms and the origin of defects and failures,
- new general railway stations.

Despite the existence of the top railway research facility VUZ in Velim, which has a test oval for trains up to 200 km/h, it is challenging if not impossible in the domestic environment to obtain the necessary experience and knowledge for HSR design, construction and operation. The search for an adequate knowledge base through the study of the latest foreign trends resulted in the development of the *Technical and Operational Study* (2017), aimed at fine-tuning the HSR design and construction parameters in Czechia. Outputs of this study laid the foundation for close cooperation with French operator SNCF, which has extensive experience in developing HSR networks in similar geographical and climate conditions. At the same time, some German technologies are

also being applied, thanks to cooperation between Deutsche Bahn and Správa železnic on the cross-border section Dresden – Ústí nad Labem (the Krušnohorský Tunnel). The knowledge obtained is currently being incorporated into the HSR design principles embedded in national standards and into the regulation documents of Správa železnic. In cooperation with SNCF, Správa železnic also created the *Manual for HSR design* at different stages of documentation preparation.

Education and training

Challenges for staffing and education policy

Given the scale of HSR design and construction, an increase in demand for qualified professionals is expected in the coming years. However, due to the unfavourable domestic and European demographic development in recent decades, and due to the general decline of interest in technical disciplines, the shortage of specialists is in fact deepening. Therefore, it is essential to focus all efforts on creating conditions for an accelerated

Given the scale of HSR design and construction, an increase in demand for qualified professionals is expected in the coming years.

Ultimately, the implementation of an interconnected HSR network is set to boost the economic, technological, cultural and demographic development in all of Europe's regions, including the whole of Central Europe.

qualitative and quantitative development of qualified human resources. However, the task of reversing the current trend is definitely not trivial and it will require long-term consistent efforts by all stakeholders (governments, contractors and manufacturers, HSR operators, educational and research institutions).

On the pan-European level, it is important to focus on:

- a greater cross-border cooperation and experience exchange between infrastructure managers ("IMs") within established railway associations, organisations and platforms (CER, EUG, UIC, RFC, RNE, etc.),
- bi-lateral cooperation at joint projects or exchange programmes,
- the best exploitation of the European ERASMUS+ programme supporting students' internships or the Multi Degree Programmes platform during the educational process.

Domestically, it is important:

- to prevent the outflow of specialists from IMs, design and construction companies in the railway industry by elaborating a system of life-long education and a set of other incentives,
- to offer better financial hinterland in the education system both for secondary schools and universities, and linkage with practice and foreign study programmes.

As stated in the 2019 *Resolution No.152 of the Economic Committee of the Chamber of Deputies of the Parliament of the Czech Republic*, initiated by the national railway technology platform "Interoperability of Railway Infrastructure", the state executive, the educational system and the commercial rail sector face a great challenge. The way this challenge is addressed will have crucial impact on further developments in the region.

Media

Further to the aforementioned barriers to higher interest in rail among young professionals, the general public's distorted perception of railways as an industry not following the latest trends also plays a significant role. The most effective way to fight-off this perception seems to be media coverage focusing on HSR as the transport system of the future with enormous innovative potential, involving state-of-the-art technologies that can offer young people attractive employment opportunities comparable to the aviation industry. However, this requires rapid implementation of a long-term, intensive and coordinated media campaign using all available means, especially social media, across all levels of the state executive, from infrastructure managers, major RUs, to individual educational institutions and other stakeholders in the railway sector.

Conclusion

Anchored in the European Green Deal, the Sustainable and Smart Mobility Strategy and the Fit for 55 Package, the effort to build an integrated HSR network in Europe represents a unique and unrepeatable opportunity to meet the EU's ambitious climate goals. Ultimately, the implementation of an interconnected HSR network is set to boost the economic, technological, cultural and demographic development in all of Europe's regions, including the whole of Central Europe.

Having stated at the very beginning of this essay that high quality, integrated, permeable, well accessible and environmentally sustainable mobility is the key to the EU's strong competitive position against other major world economies, HSR is the perfect solution to fulfil all these demands and to further propel the EU's development in the future.

List of abbreviations

B/C	Benefits / Costs
BUT	Vysoké učení technické v Brně (Brno University of Technology)
CEF	Connecting Europe Facility
CER	Community of European Railway and Infrastructure Companies
CTU	České vysoké učení technické v Praze (Czech Technical University of Prague)
CZK	Czech koruna
DB	Deutsche Bahn AG
EIA	Environmental Impact Assessment
EIB	European Investment Bank
ENPV	Economic Net Present Value
ERR	Economic Rate of Return
ERRAC	European Railway Research Advisory Council
ERTMS	European Railway Traffic Management System
EUG	ERTMS Users Group
FS	Feasibility Study
HSR	High-Speed Railway
IM	Infrastructure Manager
MoT	Ministry of Transport
PPP	Public Private Partnership
R&D	Research and Development
RC	Rapid Railway Connections
RFC	European Rail Freight Corridors
RIS3	National Research and Innovation Strategy for Smart Specialisation
RNE	RailNetEurope
RU	Railway Undertaking
SNCF	Société nationale des chemins de fer français
SZCZ	Správa železnic, státní organizace
TACR	Czech Technology Agency
TEE 2.0	Trans Europe Express 2.0
TEN-T	Trans-European Transport Network
TSI	Technical Specifications for Interoperability
TTR	Timetabling and Capacity Redesign
UIC	International Union of Railways
VUZ	Výzkumný Ústav Železniční, a. s.

References

Czech Infrastructure Association (2021): Future trends on the railway until 2050 and later. Prague, p. 23

Goverment of the Czech Republic (2019): National Investment Plan of the Czech Republic until 2050. Online: https://www.vlada.cz/assets/media-centrum/aktualne/Narodni-investicni-plan-CR-2020_2050.pdf

Ministry of industry and trade CZ (2021): National Strategy RIS3. Online: https://www.mpo.cz/assets/cz/podnikani/ris3-strategie/dokumenty/2021/1/A_RIS3-Strategie.pdf

Ministry of Regional Development CZ (2020): Policy of Territorial Development of the Czech Republic. Online: https://www.mmr.cz/getmedia/4f3be369-24df-4975-81cb-c8fb91b4e65c/PUR_CR-Uplne-zneni-zavazne-od-11_9_2020.pdf.aspx?ext=.pdf

Ministry of Transport of the Czech Republic (2013): Transport Policy of the Czech Republic for the period 2014–2020 with a prospect until 2050. Online: https://www.dataplan.info/img_upload/7bdb1584e3b8a53d337518d988763f8d/b13-00298_ministerstvo_dopravy_2014_2020_eng-05_1.pdf

Ministry of Transport of the Czech Republic (2018): Rapid Connections Development Programme in the Czech Republic. Online: https://www.mdcr.cz/getattachment/Dokumenty/Strategie/Vysokorychlostni-trate/Rapid-services-development-programme-in-Czech-republic.pdf.aspx

Ministry of Transport of the Czech Republic (2018): Transport Sector Strategy. Online: http://www.dopravnistrategie.cz/images/projekt/ke-stazeni/Aktualizace2017/III_DSS-Aktualizace2017_Materil_PoZZ.pdf

Ministry of Transport of the Czech Republic (2021): Transport Policy of the Czech Republic for the period 2021–2027 with a prospect until 2050. Online: https://www.dataplan.info/img_upload/7bdb1584e3b8a53d337518d988763f8d/iii-dp_material.pdf

Parliament of the Czech Republic (2019): Resolution No.152 of the Economic Committee of the Chamber of Deputies of the Parliament of the Czech Republic. Online: https://public.psp.cz/sqw/text/text2.sqw?idd=155122

Research, Development and Innovation Council (2019): Innovation Strategy of the Czech Republic 2019-2030. Online: https://www.vlada.cz/assets/urad-vlady/poskytovani-informaci/poskytnute-informace-na-zadost/Priloha_1_Inovacni-strategie.pdf

Key facts

The HSR network in Czechia as a part of Central Europe's integrated HSR system will provide services in two key directions:

→ **Berlin – Praha – Brno – Wien**
← **Wien – Ostrava – Warsawa**

Construction of the first sub-section (Praha – Poříčany) on the Praha – Brno axis will commence

in 2026

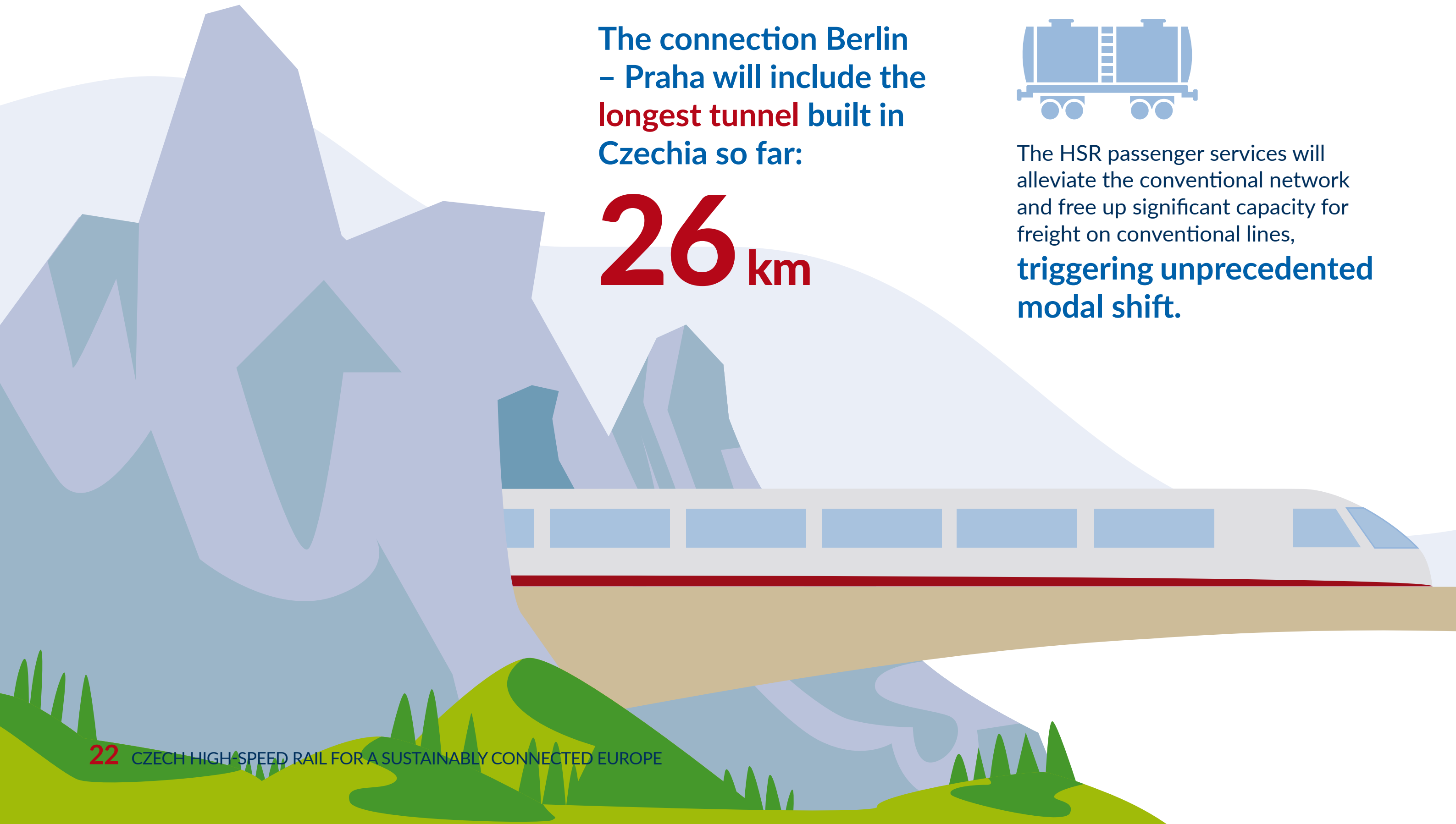
Approx. 5.5 m (~52.3 % population) will be able to reach a HSR line within

20 min.

The connection Berlin – Praha will include the longest tunnel built in Czechia so far:

26 km

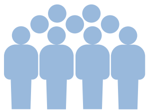
The HSR passenger services will alleviate the conventional network and free up significant capacity for freight on conventional lines, **triggering unprecedented modal shift.**



€527 mio

of estimated CO_2 savings

The modal shift on the HSR line Praha – Dresden only will yield 13.7 billion CZK (€ 527 million) of estimated CO_2 savings over 30 years of operation.



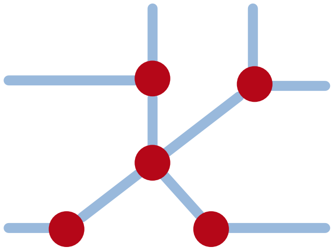
The HSR network will span approx. 660 km with speeds up to 350 km/h, carrying over

130k

daily passengers

The target travel times between the important hubs will reach in 2030 / 2040:

Berlin – Praha → 3 hours / 2 hours
Praha – Wien → 3 hours / 2 hours
Praha – Brno → < 2 hours / 1 hour



Photos © Správa železnic

Správa železnic, státní organizace (SZCZ)

Established in 2003, Správa železnic, státní organizace, is a state-owned organisation that ensures the operability, development and usage of the Czech railway network. With its more than 9,400 km-long rail network, it is one of the densest in the world today.

Správa železnic strives to create a modern, safe and environmentally sustainable transport system with high efficiency of operation, management and maintenance that offer sufficient capacity to all railroad segments. Interoperability of infrastructure, introduction of the latest technologies and preparation of a high-speed rail network are integral parts of these efforts, helping to increase the share of rail transport in the country.

Správa železnic is an active member of a number of international railway associations and platforms (eg. CER, RNE, UIC, EUG – since 2022, etc.).

The Czech Technical University of Prague (CTU)

CTU is one of the largest and oldest technical universities in Europe and one of the best technical universities in the country. Over 17,400 students study at its 8 faculties. It currently offers 271 accredited study programmes, of which 54 are in a foreign language. The Faculty of Transportation Sciences educates professionals in the field of transport and telecommunications under bachelor, master and doctoral programmes and cooperates actively on applied science research projects with leading technology, logistics and manufacturing companies and state institutions in the country.

Brno University of Technology (BUT)

With nearly 19,000 students, BUT is the largest technical university in the country, regularly achieving excellent ratings in international comparisons of universities. Its 8 faculties and 3 university institutes offer contemporary cutting-edge scientific and professional knowledge with international recognition in 295 accredited study programmes, of which 89 are in a foreign language. Students enjoy quality education in a wide range of disciplines from engineering, science, economics and arts. A significant part of BUT activities consists of R&D, taking place mainly at research centres. The University has managed, thanks mainly to grant support, to build 5 research centres of its own and in addition together with other universities and scientific institutions, it participates in the activities of 2 centres of excellence.

CER

The Community of European Railway and Infrastructure Companies (CER) brings together railway undertakings, their national associations as well as infrastructure managers and vehicle leasing companies. The membership is made up of long-established bodies, new entrants and both private and public enterprises, representing 79% of the rail network length, 77% of the rail freight business and about 90% of rail passenger operations in EU, EFTA and EU accession countries. CER represents the interests of its members towards EU policy makers and transport stakeholders, advocating rail as the backbone of a competitive and sustainable transport system in Europe.

CER
The Voice of European Railways

CER aisbl
COMMUNITY OF EUROPEAN RAILWAY AND INFRASTRUCTURE COMPANIES
Avenue des Arts, 53 1000 Bruxelles
Tel : +32 2 213 08 70
Fax : +32 2 512 52 31
contact@cer.be
www.cer.be
@CER_railways

Design inextremis.be