International System Summary: GERMANY

HighSpeedRail
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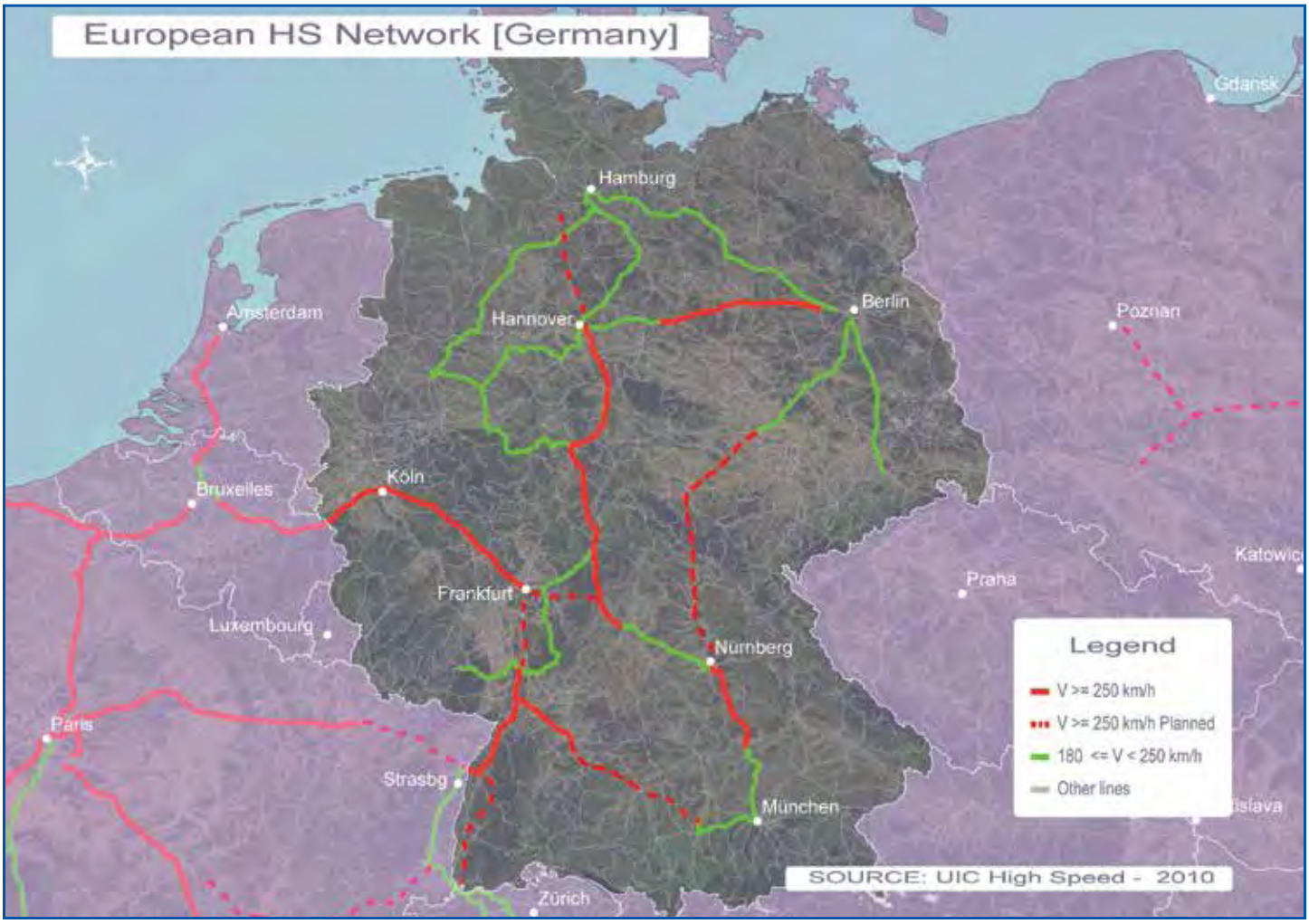


UIC Map of Germany's High-Speed Rail Lines

Germany is located in Central Europe bordering nine countries including Belgium, the Czech Republic, France, Poland, Switzerland, and the Netherlands. It ranks 16th in the world with a population of 81.3 million and is largely urbanized with 74 percent of the population residing in urban areas. The capital of Berlin is the most populated city with 3.4 million, followed by Hamburg (1.8 million) and Munich (1.3 million). Germany maintains Europe's largest economy, with a GDP of $3.085 trillion, which ranks 6th in the world. The $37,900 GDP per capita ranks 29th in the world. Almost 1,300 km (800 miles) of high-speed rail lines currently exist in Germany, with an additional 1,500 km (650 miles) either planned or under construction. The above figure displays the International Union of Railways (UIC) map of Germany's current and planned high speed rail network.

SYSTEM DESCRIPTION AND HISTORY

Beginning in the 1970s, German federal transportation plans called for high-speed rail lines in response to increasing congestion levels on the existing rail network and to make rail competitive with other modes. The first high-speed lines were built to also accommodate conventional passenger and freight train services. This incremental approach raised the conventional passenger train speeds up to 200 km/h (125 mph) on several segments. Newer lines are exclusively for high-speed train operations, with the fastest speed of 300 km/h (185 mph).

UIC Table of Germany's High-Speed Rail Lines

Stage	Speed		Year Opened	Length	
	km/h	mph		km	miles
In Operation:					
Fulda – Würzburg	280	175	1988	90	56
Hannover – Fulda	280	175	1991-94	248	154
Mannheim – Stuttgart	280	175	1985-91	109	68
Hannover (Wolfsburg) – Berlin	250	155	1998	189	117
Köln – Frankfurt	300	185	2002-04	197	122
Köln – Düren	250	155	2003	42	26
(Karlsruhe -) Rastatt – Offenburg	250	155	2004	44	27
Leipzig – Gröbers (- Erfurt)	250	155	2004	24	15
Hamburg – Berlin	230	145	2004	253	157
Nürenberg – Ingolstadt	300	185	2006	89	55
TOTAL				**1,285**	**798**
Under Construction:					
München – Augsburg	230	145	2012	62	39
(Leipzig/Halle -) Gröbers – Erfurt	300	185	2015	98	61
Nürnberg – Erfurt	250	155	2017	218	135
TOTAL				**378**	**235**
Planned:					
(Karlsruhe -) Offenburg – Basel	250	155	-	112	70
Frankfurt – Mannheim	300	185	-	81	50
Stuttgart – Ulm – Augsburg	250	155	-	166	103
Hamburg/Bremen – Hannover	300	185	-	114	71
(Hannover -) Seelze – Minden	230	145	-	71	44
(Frankfurt -) Hanau – Fulda/Würzburg	300	185	-	126	78
TOTAL				**670**	**416**
GRAND TOTAL				**2,333**	**1,450**

Several sources show high-speed passenger rail operations beginning in 1991; however, the UIC shows two segments opening prior to that time (see table above). Those initial high-speed lines now operate at 280 km/h (175 mph). The high-speed rail system, known as Intercity Express (ICE), stretches a reported 1,285 km (798 miles), with an additional 1,048 km (651 miles) under construction or planned. The table contains the current speed and length of high-speed line segments in service, the line segments under construction, and the planned segments for future development. The German high-speed network is designed to connect many hubs, including the major cities in the country and markets outside Germany.

Sources: High-Speed Lines in the World; High-Speed Rail: A Study of International Best Practices and Identification of Opportunities in the U.S.; High Speed Rail (HSR) in the United States

ECONOMICS AND FINANCE

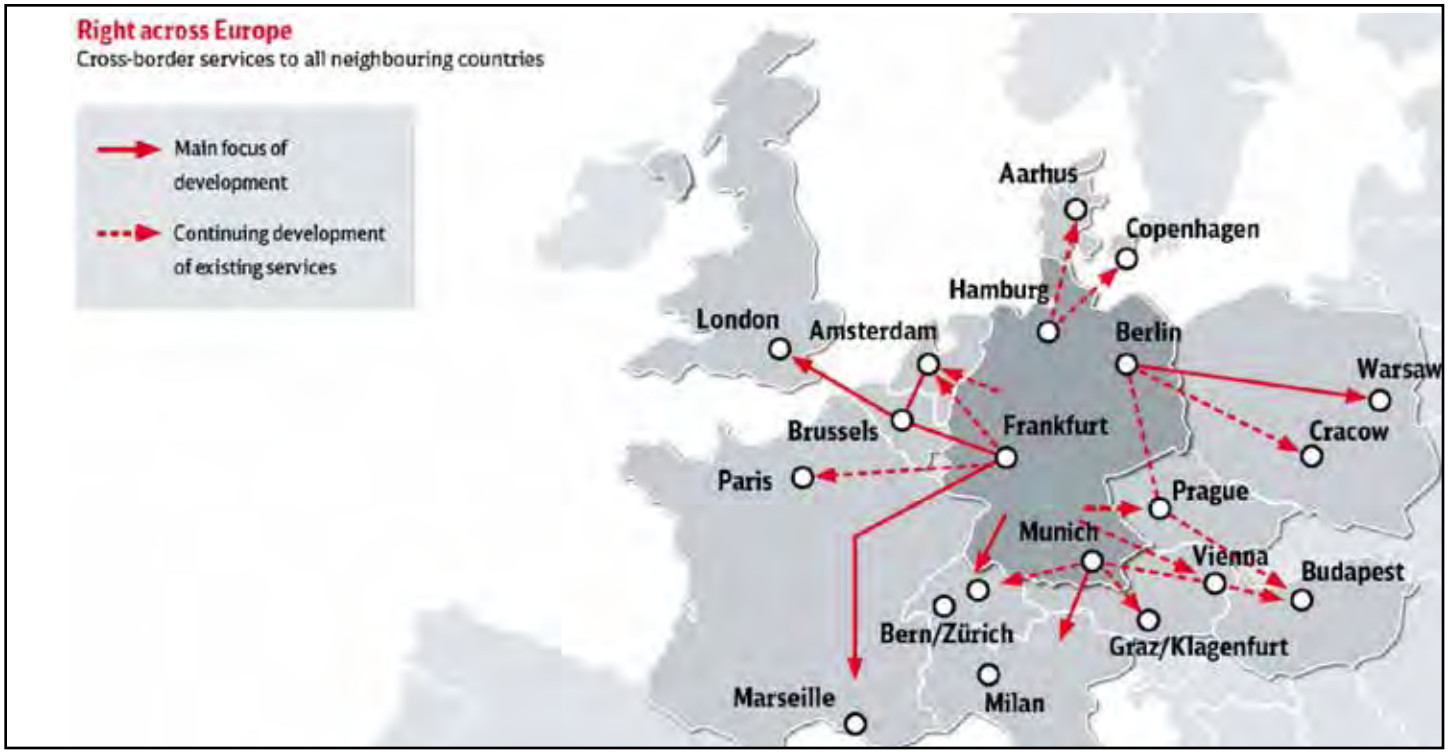
Passenger and freight rail operations are controlled by Deutsche Bahn (DB) Holdings, which was formed in 1994 following the reunification of West and East Germany. European Union directives to separate rail infrastructure ownership and operations resulted in the creation of separate subsidiaries of DB, including an infrastructure owner, DB Netze, and a train operations unit, DB Bahn, that operates regional and long distance passenger trains. DB Fernverkehr is the long distance business unit of DB Bahn where high-speed train operations are controlled. Financing for line construction comes mostly from the federal government, but also from states and local governments. Thompson (2011) also points out that because the DB Holdings conglomerate of companies is profitable, it is able to borrow on commercial markets.

Expanding ICE Services beyond Germany

Several sources highlight that DB now operates ICE trains outside of Germany. In a brochure titled, "Moving the future – Linking People," DB notes that the European Union-wide liberalization of cross-border rail passenger services provides additional opportunities to expand their services throughout Europe. They already provide ICE services to other major European cities such as Paris, Amsterdam, and Brussels but intend to expand with services between Frankfurt and London. They also already offer and plan to expand other non-ICE services including regional rail and bus services. The following map displays DB's focused array of services to other European countries.

Sources: High-Speed Rail: A Study of International Best Practices and Identification of Opportunities in the U.S.; High Speed Rail Passenger Services: World Experience and U.S. Applications; "Moving the future – Linking People"

DB Internation Service Development



RIDERSHIP AND TRANSPORTATION SYSTEM IMPACTS

The German ICE high-speed rail system has steadily grown since accounting for 5.1 million passengers in 1991, as shown in the table the right. The system carried more than 73.7 million in 2009.

The *UIC Capacity Survey Results* includes the hourly train movements along eight German high-speed rail line segments as shown in the table below. For example, the Cologne to Frankfurt segment typically had 10 trains per hour when the survey was completed.

German High-Speed Rail Line Segments Hourly Trains - 2009

Line and Section	Trains per Hour
Hamburg – Berlin	3
Berlin – Hannover	4
Hannover – Fulda	7
Cologne – Frankfurt	10
Fulda – Wurzburg	8
Nuremberg – Ingolstadt	6
Karlsruhe – Basel	4
Manheim – Stuttgart	6

Chronology of Germany's High-Speed Rail Passenger Traffic

Year	Passengers (thousands)	Passenger-Km (millions)	Passenger-miles (millions)
1991	5,100	2,000	1,243
1992	10,200	5,200	3,231
1993	14,600	7,000	4,350
1994	21,300	8,200	5,095
1995	27,259	8,700	5,406
1996	27,363	8,850	5,499
1997	30,947	10,073	6,259
1998	31,201	10,155	6,310
1999	35,642	11,591	7,202
2000	41,610	13,925	8,653
2001	46,668	15,515	9,641
2002	47,636	15,255	9,479
2003	56,480	17,457	10,847
2004	63,705	19,604	12,181
2005	66,819	20,853	12,957
2006	69,533	21,635	13,443
2007	70,531	21,919	13,620
2008	74,700	23,333	14,498
2009	73,709	22,561	14,019

An ICE 3 high speed train on the Frankfurt-Cologne high-speed rail line, near the Oberhaider Wald Tunnel

Implementation of the ICE has shifted traffic away from other modes, with the high-speed rail service between Frankfurt and Hamburg capturing 48 percent of the passenger movements. Comparing data between 1985 and 2000, the share of passengers using air reduced from 10 percent to 4 percent, while conventional rail passenger share reduced from 23 percent to 3 percent. Roadway share also reduced, from 57 percent to 45 percent. The Airfare-to-Railfare ratio on that corridor is calculated as 1.43 for business (first class) and 2.17 for non-business (second class) meaning that in both cases tickets for rail travel are significantly cheaper than tickets for air travel.

The UIC report *High Speed Rail and Sustainability* discusses how the high-speed rail system is part of a combined multimodal travel chain. Passengers are able to attain door-to-door travel information by obtaining online timetables including all modes of public transport and maps that can be used to walk the final journey segments. The report also highlights that "holders of the German BahnCard can change from long-distance high-speed rail trains to regional public transport at their final destination for no extra charge and without an additional ticket, since the 'City-Ticket' is automatically included." DB Mobility Logistics states that 4.4 million customers make use of the BahnCard. A final multimodal aspect of the German high-speed rail network is replacing short distance flights with rail between Cologne or Stuttgart and Frankfurt Airport where the air ticket becomes a train ticket.

Berlin High-Speed Train Stations

The UIC report *High Speed and the City* documents how high-speed rail stations relate to city planning and development through a series of case studies. One of the case studies examined is Berlin. It notes that the Berlin metropolitan area population is approximately 4.3 million people, with the city itself having an estimated population of 3.4 million people. The population density within the city is calculated as 3,848 people per square kilometer (10,031 people per square mile). For comparison, other city densities reported by UIC include Paris with 1,971 people per square kilometer (5,138 people per square mile) and Tokyo with a density of 14,254 people per square kilometer (37,158 people per square mile).

The case study indicates that prior to 2006 high-speed train service existed at three stations (Zoologischer, Ostbahnhof, and Spandau). With the opening in 2006 of a

second four track north-south line, including new tunnels under the Spree River, and opening of the Hauptbahnhof Central Station, operational changes now bring all high-speed train services through the Hauptbahnhof Central Station. On a daily basis, approximately 39,000 passengers are served from 232 high-speed services. The estimated construction cost of the new Hauptbahnhof Central Station is 1 billion Euro ($1.3 billion)*. The other Berlin-area ICE stations include Gesundbrunnen, Ostbahnhof, Sudkreuz, and Spandau.

The UIC *High Speed and the City* document highlights the improved connectivity and services resulting from the construction of the Hauptbahnhof Central Station and restructuring of the high-speed services through the city. With stops at multiple DB stations in Berlin and all connecting to the Hauptbahnhof Central Station, the operator was able to "offer more services, carry more passengers using less number of trainsets, and give the passengers the option of getting off/on the train in more city points, making the transfer shorter and more convenient." Berlin also has subway lines, commuter rail lines, light rail tram lines, and bus services.

Another aspect of the Hauptbahnhof Central Station is the central position within the city with a location near the Reichgstag, the Spree River, and government buildings. Development plans exist for the station area including two towers for DB offices and hotels at and adjacent to the station. Additionally, commercial space exists at the station for "a business mix of 80 shops, catering outlets, and service facilities."

As part of the case studies, the UIC provides a modal comparison between the focal station and first station. In this case the comparison is between Berlin and Hannover, a distance of 189 km (117 miles). The following chart provides the estimated travel times and travel cost for the different modes of travel. High-speed train service covers the distance in only 1 hour 30 minutes compared to car at 2 hours 30 minutes at a lower cost. Travel by airplane was not included in the analysis.

UIC Berlin Hauptbahnhof Station to Hannover Modal Comparison

Travel Mode	Travel Time	Travel Fares*
High-Speed Train	1 hr 30 min	61 Euro ($79)
Conventional Train	5 hr	41 Euro ($53)
Car	2 hr 30 min	65 Euro ($84)
Plane	–	–

Sources: Economic Analysis of High-Speed Rail in Europe; High Speed Rail Passenger Services: World Experience and U.S. Applications; Capacity Survey Results; High Speed Rail and Sustainability; Did You Know That…; High Speed and the City

ICE 3 Class 403 reflection on window during overtaking on the high-speed line Nuremberg - Ingolstadt (Copyright Deutsche Bahn AG)

SUSTAINABILITY

In 2005 DB developed a company-wide sustainability management system. Sustainability reports, beginning in 2007, highlight the extent of this system and how DB takes its social responsibility seriously. DB states that its business model "ensures sustainable mobility and logistics for both customers and society, for economic success and jobs." Maintaining and expanding environmentally friendly rail service, both passenger and freight, is a major component of their sustainability objectives. Their sustainability strategy focuses on climate, resource, and noise protection.

Climate

Increased electrification of the rail network since 1990, now at just under 60 percent, has resulted in a reduction of particulate emissions in rail transportation by 89 percent and nitrogen oxide emissions by 71 percent. DB indicates that over 90 percent of their rail transport performance is rendered using electric vehicles. For CO_2 emissions, since 1994 DB has reduced the CO_2 emissions from rail per passenger and ton-kilometers, which is referred to as the specific CO_2 emissions, by approximately 33 percent. By 2020, it wants to reduce CO_2 levels by another 20 percent, and by 2050 DB wants to be entirely CO_2-free for rail transportation. To achieve this, it wants to increase the percentage of renewable energy in the trac-

Hamburg Central Station

tion current mix to at least 35 percent and 100 percent by 2050. The 2010 level is 19.8 percent. DB highlights wind power as one renewable energy source of the future and already has 25 wind turbines under contract that generate 74 gigawatt-hours (GWh) of electricity per year on average.

In order to promote sustainability, DB offers its passenger transport and rail freight transport customers CO_2-free trips. Offered since spring 2009, the program works by "DB Energy purchasing the electricity needed for the programs from renewable energy sources in advance specifically for this purpose and feeds it into the traction current grid." Jehanno et al. (2011) points out that a small extra fee equal to approximately 1 percent of the travel costs is added.

Resources

In considering resource efficiency, DB notes that "materials are refurbished and reused as often as possible, and priority is given to salvaging unavoidable waste and feeding it back into circulation as secondary raw materials." These practices reduce the amount of waste produced and has increased the recovery rate to its present level of 80 percent.

Noise Protection

Rail noise is largely a freight rail issue but many of DB's efforts to reduce noise will also improve noise levels for passenger rail services. DB's noise remediation program includes both traditional noise reduction measures and equipment enhancements. They want to reduce the 2020 rail noise levels by half compared to year 2000 levels. In the brochure "Facts and Figures about Sustainability 2010," DB identifies building noise barriers and sound-proof windows as traditional measures installed along over 160 km (99 miles) of track in 2010, which equates to 28 percent of the track identified in the noise remediation program. The "Summary Sustainability Report 2009" comments on the purchase of new freight rail cars fitted with whisper brake blocks that reduce by half the perceived rolling noise in conjunction with a smooth track.

Sources: High Speed Rail and Sustainability; "Summary: Sustainability Report 2009"; "Did You Know That…"; "Facts and Figures about Sustainability 2010"

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