HIGH SPEED PASSENGER RAIL SYSTEMS

Research Report

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Overview of High Speed Rail

Definition of High Speed Rail

The European Union defines high speed rail as lines specially built for speeds greater than or equal to 250 km/h/155 mph, or lines that are specially upgraded with speeds greater than 200 km/h or 124 mph. The U.S. defines high speed differently. *Emerging* rail has speeds of 90 to 110 mph; *Regional* rail has speeds of 110 to 150 mph; and *Express* rail has speeds of at least 150 mph.[1]

Types of High Speed Rail

- Dedicated: this model has separate high-speed tracks that exclusively serve high-speed trains, example: Japan's Shinkansen.
- Mixed high-speed: this model includes both dedicated, high-speed tracks that serve only high-speed trains and upgraded, conventional tracks that serve both high-speed and conventional trains, example: France's TGV (Train à Grande Vitesse).
- Mixed conventional: this model has dedicated, high-speed, standard-gauge tracks that serve both high-speed and conventional trains equipped with a gauge-changing system, and conventional, nonstandard gauge tracks that serve only conventional trains, example: Spain's AVE (Alta Velocidad Española).
- Fully mixed: most of the tracks in this model are compatible with all high-speed, conventional.
- Passenger and freight trains, Example: Germany's ICE (Inter-City Express).

High Speed Rail Mileage by Country In Operation and Under Construction			
Country	**HSR Mileage**	**Country**	**HSR Mileage**
Algeria	41	Poland	139
Austria	331	Portugal	657
Belgium	130	Russia	733
Bulgaria	286	Saudi Arabia	273
China	12,625	South Korea	444
Denmark	37	Spain	2,326
France	1,617	Sweden	537
Germany	876	Switzerland	66
Greece	354	Taiwan	749
Italy	891	Turkey	214
Japan	1,966	United Kingdon	978
Netherlands	75	Uzbekistan	214
Norway	39		

Source: International Union of Railways

[1] International Union of Rails, *General Definitions of High speed*, (Paris, 2012)

Major Countries' High Speed Rail System(s)

China, France, Germany, Italy, Japan and Spain have six of the most extensive high-speed rail systems in the world. The first high-speed rail line opened in Japan for the 1964 Olympics. Europe's first high-speed rail line opened in Italy between Rome and Florence in 1978. In Europe, each country's national rail company operates high-speed rail service. These operator-owned trains serve several countries creating a seamless network. For example, France's TGV line also operates in Belgium.

Japan. The world's first high-speed rail line, known as the Shinkansen, was built in 1964 between Tokyo and Osaka, Japan. This line was built in a corridor well suited to rail travel, and the train was built to expand capacity on an overcrowded route. Construction was financed with loans from the World Bank and the Japanese government. The railway repaid the loans in seven years. After that, operating profits on the line were used to cross-subsidize local trains. The success of this line encouraged expansion, and the Japanese government continued to build high-speed lines throughout the country. The Sanyo, the second line, came close to breaking even, but none of the other lines generated enough passenger revenue to cover their operating costs, not to mention their capital costs.

Partly as a result of large operating losses as a public entity, Japan National Railways was privatized in 1987. Since 1987, extension of high-speed lines has continued, supported by the notion that infrastructure spending stimulates the economy. The company is now highly profitable. Some of the newer lines that end in smaller cities require Tokyo-bound commuters to transfer trains at least once. These lines have very low ridership totals. New lines constructed today are funded by public-private partnerships, with part of the funding coming from the now-privatized regional rail companies, and the rest from the national and local governments. The current network features almost 1,500 miles of track with top speeds of 149–183 miles per hour, and more lines under construction. Shinkansen technology is not limited in Japan. China, United Kingdom already have trains based on Shinkansen technology. Canada, United States, India, and Vietnam all have good discussions with Japan about importing Shinkanse technology to build their high speed rails.

Italy. The world's second high-speed rail line opened in Italy between Rome and Florence in 1977. Italy now has two lines: one connecting Turin and Venice and the second linking Milan to Salerno. Parts of the Milan to Salerno line remain under construction. Italy has slowly expanded its track to connect most major cities by high-speed rail. However, it has not expanded rapidly over the past 20 years. Early in 2012, the Nuovo Trasporto Viaggiatori private train operator began competing with the state-run Trenitalia for domestic rail service. This makes Italy the first country in the world where two high-speed rail services compete against each other. It will be interesting to see if this competition reduces the costs of high-speed rail travel.

France. France built the world's third high-speed rail system. Referred to as TGV (Train à Grande Vitesse) the first line opened in 1981, between Paris and Lyon. As of 2011, the French system had approximately 1,270 miles of high-speed rail line. Unlike the Japanese system, which features a linear design where some lines do not connect with Tokyo, the French system has spokes radiating outward from the hub of Paris. According to the French rail operating company, SNCF, its TGVs have taken over 90% of the combined air-rail travel market for the Paris-Lyon route, which has a TGV travel time of less than two hours. TGV also has about 60% market share in corridors where the TGV travel time is around three hours. France's system has been expanded to Belgium, Germany, Italy and Switzerland. As of 2011, the French system is the longest in Europe at more than 1,250 miles and operates at top speeds around 200 miles per hour.

China. High-speed rail (HSR) in China refers to any railway in China with commercial train service at the speed of 200 km/h (124 mph) or higher. By that measure, China has the world's longest HSR network with over 16,000 km (9,900 mi) of track in service as of December 2014 which is more than the rest of the world's high speed rail tracks combined. China's high speed rail system also includes the world's longest line, the 2,298 km (1,428 mi) Beijing–Guangzhou High-Speed Railway. Since high-speed rail service in China was introduced on April 18, 2007, daily ridership has grown from 237,000 in 2007 to 2.49 million in 2014, making the Chinese HSR network the most heavily used in the world.

The nationwide HSR network, which extends to 28 of the country's 33 provinces and regions, consists mainly of conventional track railways including upgraded mixed passenger and freight lines, newly-built passenger designated lines (PDLs) and intercity lines. There is also the Shanghai Maglev, the world's first high-speed commercial magnetic levitation (maglev) line, which is owned and operated by the Shanghai municipality government. Nearly all high-speed rail lines and rolling stock are owned and operated by the China Railway Corporation, the state enterprise formerly known as the Railway Ministry.

China's early high-speed trains were imported or built under technology transfer agreements with foreign train-makers including Alstom, Siemens, Bombardier and Kawasaki Heavy Industries. Chinese engineers then re-designed internal train components and built indigenous trains that can reach operational speeds of up to 380 km/h (240 mph).China is planning to develop the largest high-speed rail network in the world. China's rationale is that HSR will (1) relieve the pressure of both passenger and freight demand on its overcrowded existing rail system; (2) improve transportation connections between the country's different regions; and (3) promote the economies of less developed regions. China is upgrading existing lines and building new dedicated electrified lines. Some upgraded lines will have speeds of 120–150 mph, while other upgraded lines and all new dedicated lines will have speeds up to 186 mph. In 2008, China's government announced plans to have approximately 10,000 miles of high-speed lines (including both upgraded existing lines and new dedicated electrified lines) in operation by 2020.

Germany. Encouraged by high-speed rail in France and Italy, German leaders made high-speed rail a national priority. As a result, Article 87 of the German Constitution makes rail transport a government responsibility. Construction on Germany's Inter City Express (ICE) high-speed rail system began two years after French construction. However, lawsuits slowed construction and the first high speed rail line connecting Hamburg and Munich did not open until 1991.The German network varies significantly from that of its neighbor, France.

As a result of political demands and a denser population, Germany's high-speed rail service has been developed to connect many hubs, unlike the French network, which radiates out from Paris. Germany's high-speed trains have more stops than those of France, where the system emphasizes connecting distant city-pairs with few intermediate stops. Initially, Germany preferred upgrading existing rail lines to accommodate higher speed service, rather than building new lines. In these cases, Germany's high-speed trains have longer average trip times than French trains over comparable distances. As many of the older lines have now been upgraded, most of the lines built in the past 5–10 years are new lines. As of 2007, Germany had 11 different high-speed rail lines at a total length of more than 810 miles. Many of Germany's upgraded lines have a top speed of 155 miles per hour. All new lines and some upgraded lines can reach 186 miles per hour.

Russia. High-speed rail is emerging in Russia as an increasingly popular means of transport. Two experimental high-speed trainsets were built in 1974 designed for 200 km/h (120 mph) operation: the locomotive-hauled RT-200 ("Russkaya Troika") and the ER-200 EMU. Both sets retired.

The Sapsan on the Moscow–Saint Petersburg Railway is Russia's highest speed railway with a top speed of 250 km/h (155 mph).The first upgraded 250 km/h service using Siemens Velaro RUS trains went into service on December 26, 2009.

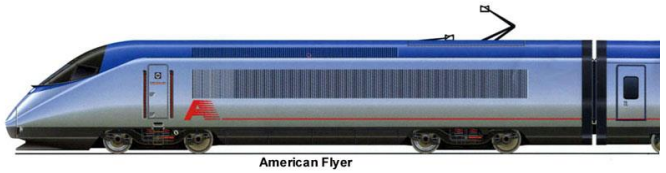
Helsinki–St. Petersburg: 200 km/h (124 mph) high-speed service using Karelian Trains Class Sm6 (Allegro) trains started on December 12, 2010, reducing travel time from 5.5 hours to 3.5 hours. The trains run at 200 km/h (124 mph) on most of the Russian part, and 220 km/h (137 mph) on a short stretch in Finland.

Moscow–Nizhny Novgorod: High-speed traffic in Nizhny Novgorod began in July 2010. Two Sapsan trains make shuttle trips between Nizhny Novgorod and Moscow, and one between Nizhny Novgorod and St. Petersburg. The latter route takes 8 hours and 30 minutes, compared to the previous 14 hours. Moscow-Kazan High-Speed Rail Project. The call to build this 770 kilometers, 2018 completed rail line that would connect Kazan and Moscow was first announced by President Vladimir Putin in the Economic Forum at St. Petersburg in 2013. Plans for the railroad estimate that it will be the first true high-speed line in Russia with trains operating at up to 400 kilometers per hour. A rail trip from Moscow to Kazan which today takes a close to 13 hours trip, would be reduced to 3.5 hours. With the Moscow-St. Petersburg line on the other hand trains run at up to 240 kilometers per hour.

Spain. Spain opened its first high-speed rail line—AVE (Alta Velocidad Española)—in 1992. Spain has two separate rail networks. The country chose to build its conventional rail network using a wider gauge than the international standard. But in order for Spanish trains to function on other countries rail lines, its high-speed rail network is being built to the international standard. As a result, many trains must have special equipment to allow them to operate on both networks. As of 2011, Spain's high-speed rail system was 1,656 miles in length, making it the second longest system in the world after China. Spanish trains operate at top speeds between 155 and 200 miles per hour.

Since 2003 Spain has been spending more money on rail than on roads. The Spanish government's Ministry of Public Works has a Strategic Plan for Infrastructure and Transport for the period from 2005 to 2020. The largest spending category—$146 billion (44% of the total)—is for railways. Spain's plan is to increase the size of the high-speed rail network to 6,200 miles by the year 2020, and place 90% of the population within 30 miles of a station.

United States. There is one high-speed rail service in operation, the Acela Express running in the Northeast Corridor. There are plans for higher-speed rail and high-speed rail in California, the Midwest, New England, Florida, Texas, Pennsylvania, the Pacific Northwest, Colorado/ New Mexico, and the Southwestern United States.



American Flyer

Acela Express

As of 2015, the California High-Speed Rail Authority is beginning construction on the California High Speed Rail project, which is planned to link Anaheim, San Francisco, San Jose, Sacramento and other major cities in the state. It will take at least until 2029 to complete, with its first stage targeted for completion in 2017.

India. Majority of India's railway system was built by the British during the last two centuries. While India has one of the largest rail networks in the world, as of 2015 it does not have any kilometers classed as high-speed rail (HSR). China and India start discussing jointly building India's first high-speed railway, a 1,754-kilometer track from Delhi to Chennai that could cost 200 billion yuan ($32.6 billion) in November, 2014. High-speed rail trains would travel at speeds up to 300 kilometers an hour on the line between India's capital and the southern commercial and industrial city. If completed, the deal would allow Chinese companies, notably China Railway Construction (601186:CH) (CRCC), to provide newly designed railway tracks, automated signaling equipment, and modern stations that India's rail system desperately needs.

Profiles of Rail Vehicles Manufacturers

Kawasaki and other Japanese Firms (Japan). The rail manufacturing operations of these firms are part of large Japanese industrial conglomerates. For example, Kawasaki Heavy Industries' rail division has produced more than 90,000 rail vehicles since 1906. Japan's rail manufacturers are designing and building slower-speed trains individually. High-speed trains for domestic use, by contrast, have been built by a variety of consortia, including Nippon Sharyo, Hitachi, Kawasaki, Mitsubishi, Kinki Sharyo, and Tokyo Car Corp. Given a limited market in Japan, rail manufacturers are increasingly pursuing export markets for their HSR trains. Orders have been secured in Taiwan, China, India, and the United Kingdom, and Japanese companies are competing for contracts in Brazil, Vietnam, and the United States.

China South Locomotive and Rolling Stock; China Northern Locomotive and Rolling Stock (China). CSR and CNR were established in 2001, emerging from the former China National Railway Locomotive & Rolling Stock Industry Corporation (LORIC). Nationally, CSR leads in the production of electric locomotives, high-speed electrical multiple units (EMUs), and some types of subway vehicles. CNR is strong in the production of diesel locomotives, very-high speed EMUs, and certain types of subway cars. Both companies are engaged in HSR manufacturing joint ventures with the leading international rail manufacturers via subsidiaries Changchun, Tangshan, and Sifang. CSR and CNR officially announced on Dec 30, 2014 that they would merge into a new company, which will inherit both companies' assets, liabilities, businesses, staff, contracts, certificates as well as all other rights and obligations.

Siemens (Germany). A large German industrial conglomerate, Siemens was set up in 1847 and is currently involved in building Germany's ICE 2 high-speed train, along with Bombardier's Adtranz. It has received large orders for the ICE 3 (and a variant, the Velaro) in Germany, Austria, the Netherlands, Spain, Russia, and China, with China's order of 1,000 cars representing the single largest order of HSR trains ever. Siemens designed and built the Maglev train in Shanghai, the only system in operation to date using this technology. In the United States, Siemens is building its S70 light rail vehicle in Sacramento, California.

Bombardier (Canada). Founded in the 1940s, Bombardier entered the rail business in the 1970s. Its transportation division is headquartered in Germany. As the world's largest rail manufacturer, Bombardier has 59 production and engineering sites and 20 service centers in 25 countries. More than 100,000 of its rail vehicles are in use worldwide. Altogether, Bombardier has sold more than 2,500 trams and light rail* vehicles to about 100 cities worldwide. It supplied a total of more than 3,000 subway cars to the United Kingdom, China, and India, and is a major supplier of commuter and regional trains in France and Germany. Via various consortia, the company has been involved in the delivery of 850 HSR vehicles worldwide, including the TGV in France, AVE in Spain, ICE in Germany, ETR in Italy, and CRH 1 in China. Bombardier (along with Alstom) built Amtrak's Acela Express.

Alstom (France). Formed in 1928, Alstom started rail manufacturing in 1932 and is headquartered in France. Alstom developed France's high-speed TGV in the 1960s and introduced the even faster AGV, with top speeds of 225 miles per hour, in 2008. More than 400 TGVs made by Alstom are in service in France, and 640 worldwide (including in the United Kingdom, the Netherlands, Spain, and South Korea). Alstom leads the $3 billion global very-high-speed market and has built 70 percent of the trains in service worldwide that travel faster than 185 miles per hour. It is the second largest tram manufacturer worldwide, accounting for 22 percent of the $5.3 billion annual world market, and has delivered more than 930 vehicles. Alstom is also the second largest manufacturer of subway vehicles, with more than 2,000 cars sold to 45 cities since 1997.

Talgo (Spain). Talgo is a Spanish manufacturer of intercity, standard, and high speed passenger trains, established in 1942. Talgo offers passenger trains, passenger coaches, high speed trainsets, high speed trains, and maintenance equipment. It also provides maintenance services, such as preventive maintenance, including FRA daily inspections; and on-board technicians, corrective maintenance, interior and exterior cleaning, predictive maintenance, condition based maintenance, modification, large scale repairs, overhaul, and maintenance engineering. Talgo trains are divided into a number of generations. They come in both locomotive hauled and self-propelled versions.

AnsaldoBreda (Italy). AnsaldoBreda, A Finmeccanica Company, was created by the merger of two leading Italian companies, Ansaldo Trasporti and Breda Costruzioni Ferroviarie in 2001. With current fleets operating in Washington DC, Atlanta, Boston, Cleveland, Los Angeles and San Francisco, AnsaldoBreda is the largest modern day supplier of transit rail cars in the United States outside of the populous New York metropolitan area. The company designs and manufactures railway and mass transit vehicles and is part of the Finmeccanica group. On 24 February 2015, Hitachi announced it had entered into an agreement to buy AnsaldoBreda from Finmeccanica. The company has production sites in Pistoia, Napoli, Reggio Calabria and Palermo and is also present in Spain and in the United States. AnsaldoBreda's projects include: Sirio trams, driverless metros, regional trains and high-speed trains (including the brand new Frecciarossa1000, capable of reaching 400km/h and to be the fastest train in Europe).

Transmashholding (Russia). CJSC Transmashholding is the largest manufacturer of locomotives and rail equipment in Russia, with annual sales of US $3.2 billion and a workforce of 55,000 people in 2008. The Company includes 14 engineering and production sites in Russia and one production and engineering site in Germany. The company actively works with JSC Russian Railways, the Ministry of Transportation of the Russian Federation, and other Russian Federation ministries, including Ministry of Industry and Power, Ministry of Economic Development and Trade, and Ministry of Finance. Russian Railways is the company's biggest customer. Transmashholding has major customers in Bulgaria, Belarus, Kazakhstan, Ukraine, and Serbia. They manufacture and sell subway cars, passenger diesel locomotives, diesel engines, freight cars, flat cars, and diesel trains.

Škoda Transportation (Czech). Škoda Transportation is a Czech engineering company based in Plzeň. Its operations are in the area of transport engineering, manufacture of rail vehicles for urban and railway modes of transport, traction motors and drives for transport systems in the tradition of Škoda manufacturing plants. It has a strong footprint in the local and international market. In 1974 and 1979 Škoda produced 12 Škoda 66E locomotives capable of a speed of 200 km/h (124 mph) for the Soviet Union. These were designated as Chs200 and were used mainly on the Nevsky Express train on the Moscow – Saint Petersburg Railway. The locomotives were refurbished in the 1990s and during testing in 2007 one locomotive reached a speed of 262 km/h (163 mph). Since 2008 Škoda has been producing Skoda 109E locomotives capable of a speed of 200 km/h (124 mph). The ČD Class 380 batch is certified for that speed, just as future DB Class 102, however the Slovak ZSSK Class 381 batch only for a speed of 160 km/h (99 mph). Along with DB Class 102 will be delivered batch of double decker trainsets with construction speed of 200 km/h (124 mph), although legislatively limited to 189 km/h (117 mph).