

Fast Tracks: A Comparison of High Speed Rail in China, Europe and the United States

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ABSTRACT

High speed rail systems have blossomed in technological advances since their debut in the 1960's with the Japanese Shinkansen line. As miles upon miles of tracks increase around the world, bringing added mobility to travelers while decreasing emissions, various technologies are leading the way to a faster tomorrow. This article explores the differences in what countries around the world are using to supply the next generation of travel modes. This paper details the differences in technological implementations from Asia, Europe, and North America. High speed rail systems are far more developed in other countries, especially China, and have required substantial government investment. The United States, with limited HSR development, stands to benefit from the technological advances of others and learn from the economic impacts of HSR in other countries.

Keywords: High Speed Rail

1. Introduction

High speed rail has the potential to be a great transportation asset to travelers, economies, and the environment. Where implemented, it has typically become the preferred transit mode. It is a technology that has been used throughout various countries, some with more success than others, starting as early as the 1960's [1]. In high density areas, especially those with high volumes of traffic and congestion, a well-developed rail system is a very desirable mode of transportation. In an age of mobility and increased air quality concerns, many are finding high speed rail to be a viable and enjoyable alternative to automobiles and plane travel. Though high speed rail is capable of drastically reducing travel times with maximum speeds well into the 450 km/h range or higher, tradeoffs exist in speed versus energy consumption. This still leaves travelers with a transportation option, however, of speeds over 300 km/h in many circumstances, drastically reducing the time to a destination. They are investments that take decades to realize a return on investment, but some nations are beginning to see their lines pay off and begin to profit.

Countries with well-developed networks of HSR have seen various types of economic impact. Many have ex-

perienced the strengthening of their large, globally active city centers and business hubs as transportation between major cities has become simplified and faster [2]. Many of the dense cities in Europe and Asia were experiencing strong air pollution and traffic congestion issues. High speed rail reduces both of these issues with lower emissions and an attractive and often faster mode of transportation to travelers and workers [2]. Rail networks are not only linking major cities in European countries, but those in other countries as well as the network grows to span across the region. In this article, the various technologies and economic impacts will be reviewed and compared to examine how HSR is changing the global transportation scene.

2. Asia

Figure 1 on the next page shows the HSR network in Asia. Japan debuted the first high speed rail system in 1964 with speeds of about 210 km/h [1]. Compared to other modern systems, this speed would be considered somewhat modest for current technology, but it held the top spot in the World Speed Survey until 1981 [3]. Also, it sparked an interest for nations around the world in the consideration of long distance travel. The Shinkansen tracks of Japan have grown to stretch fourteen hundred

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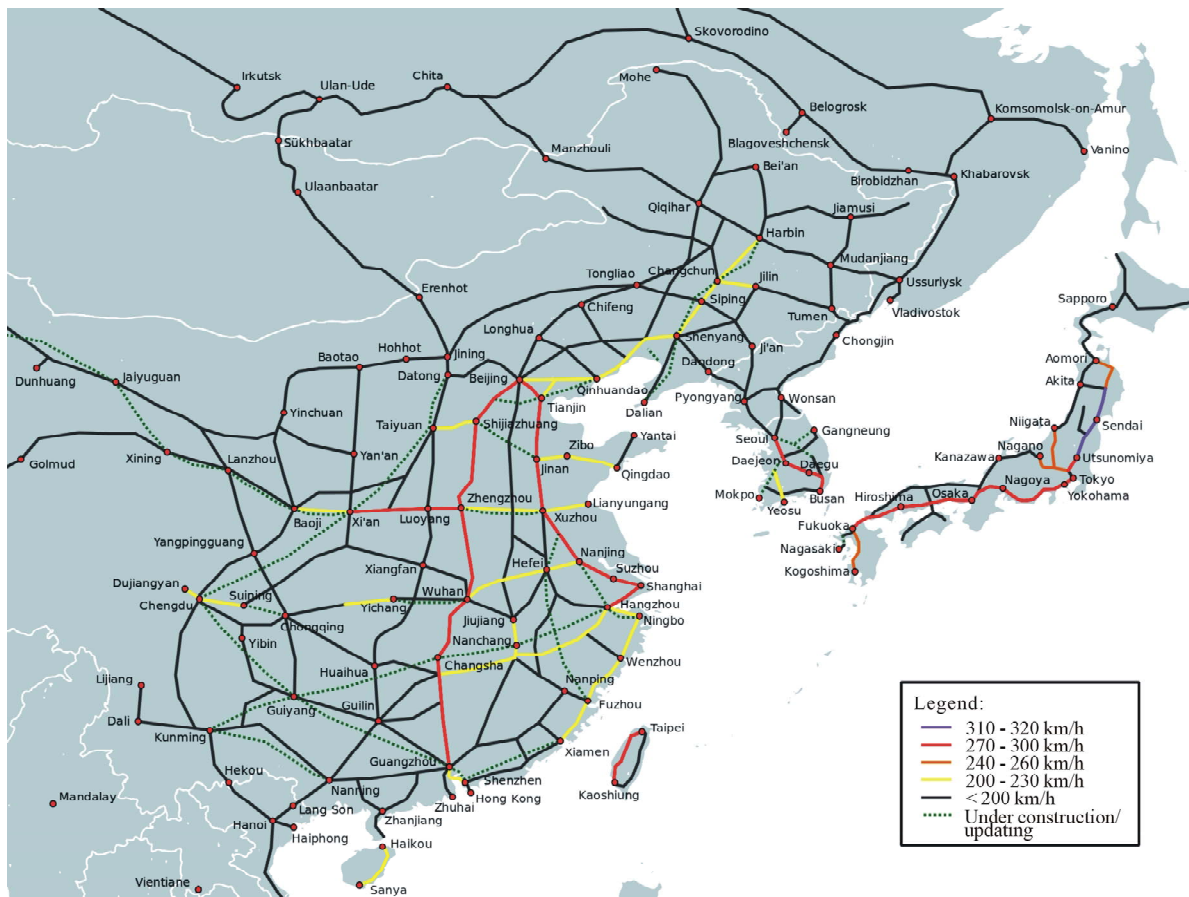


Figure 1. Network of high speed rail systems throughout Asia [16].

miles with speeds slightly under 325 km/h. The electric trains contain powered axles beneath the train, whereas other countries implemented locomotive-powered, fast trains [1]. Lightweight designs and low maintenance are strong advantages to the Shinkansen technology. Also used in Shinkansen designs is distributed traction, which increases payload space, powers more axels for better adhesion, and regenerative braking systems that turns slowing down into an energy source [3].

High speed rail (HSR) has become an effective mode of transit in many Asian communities. In Taiwan, HSR has brought many of the major cities and surrounding areas to a travel time of less than one hour, and has connected Kaohsiung and Taipei with a 90-minute trip instead of the previous 4.5-hour railroad trip [4]. Approved in 1995, the HSR in Taiwan was the first major infrastructure project to be undertaken using a Build-Operate-Transfer model [5].

The Taiwan High Speed Rail (THSR) is a 345 km rail corridor designed for maximum speeds of 350 km/h, with 75% of the line operating on elevated bridges [5]. The Taiwan HSR system involved an investment of approximately \$16 billion [6]. The THSR connects areas of manufacturing, business, and administration to bring the

export-dependent country within closer operating of its various sectors. Shifts in urban land uses in this region have followed with transportation shifts (e.g. centered on harbors and ports changing to centered on rail stops). The THSR technology is mostly imported and based on the Shinkansen line of Japan, with management systems implemented from European technology [4].

As the rail is located throughout a geologically active area between two subduction zones, it was important to implement designs that could withstand seismic activity. The Tuntzuchiaio Fault crosses the HSR line, requiring special engineering for various sections. This prompted special height minimums on earthen embankments and specific bridge supports with some components being somewhat elastic to particular directions of movement so that major loss of life and bridge failures could be avoided.

By far the most extensive high speed rail system is in China. China rail systems are comprised of a variety of different technologies. The Chinese HSR (CHSR) networks synthesize technology from Japan, Germany, and France, while adding in innovations of the country's own [7]. The Shanghai Maglev debuted in 2003 and runs on technology from a German company, reaching top speeds

of 430 km/h [8]. The CHSR line running from Wuhan to Guangzhou is a locally built combination of the Japanese Shinkansen and German ICE trains, with some variations [9].

Obstacles China had to overcome in the quest for leading the world in HSR included topography and geology. The extensive networks race over starkly different geologic bases and large spans of rivers. Three of the HSR bridges in China hold records for span, width, and capacity [7]. Extreme technological precedents were also set in the tunnel construction and speed (up to 350 km/h) through the tunnels of the trains. The CHSR tracks, unlike others using repurposed tracks, was a ground-up design that allows for top speeds over a range of obstacles without having to slow down as repurposed lines require [9]. China uses ballastless tracks that do not use rock material to stabilize them and also has track networks that are seamless, a feat that required heavy research due to varying temperatures across the country [7]. The Chinese rails are nearly all set in concrete slabs of German design, which reduce wear and tear on the wheels and tracks [9]. Chinese-made trains operate worldwide

and remain the fastest.

3. Europe

Figure 2 shows the network of HSR throughout Europe. In Europe, there are differences in how high speed rail systems are done from details of the larger system down to the way power is supplied. England tends to use a smaller voltage than the norm for the rest of Europe (e.g. 1.5 kV for Europe and 750 V for England as typical norms). Similarly, HSR in England supplied power via a third rail, whereas other European countries use overhead delivery of power [8]. Some of Europe's old diesel train lines are still in operation, as the fastest diesel trains in operation [1]. In Europe, interconnectivity has grown up alongside high speed rail, with the European Union encouraging the construction of tracks along lines that would be beneficial to national governments. This has given rise to safety and operation standards that are cohesive between countries [1]. European HSR is operated almost entirely on a for-profit basis that does not utilize government subsidy. England's rail system was con-

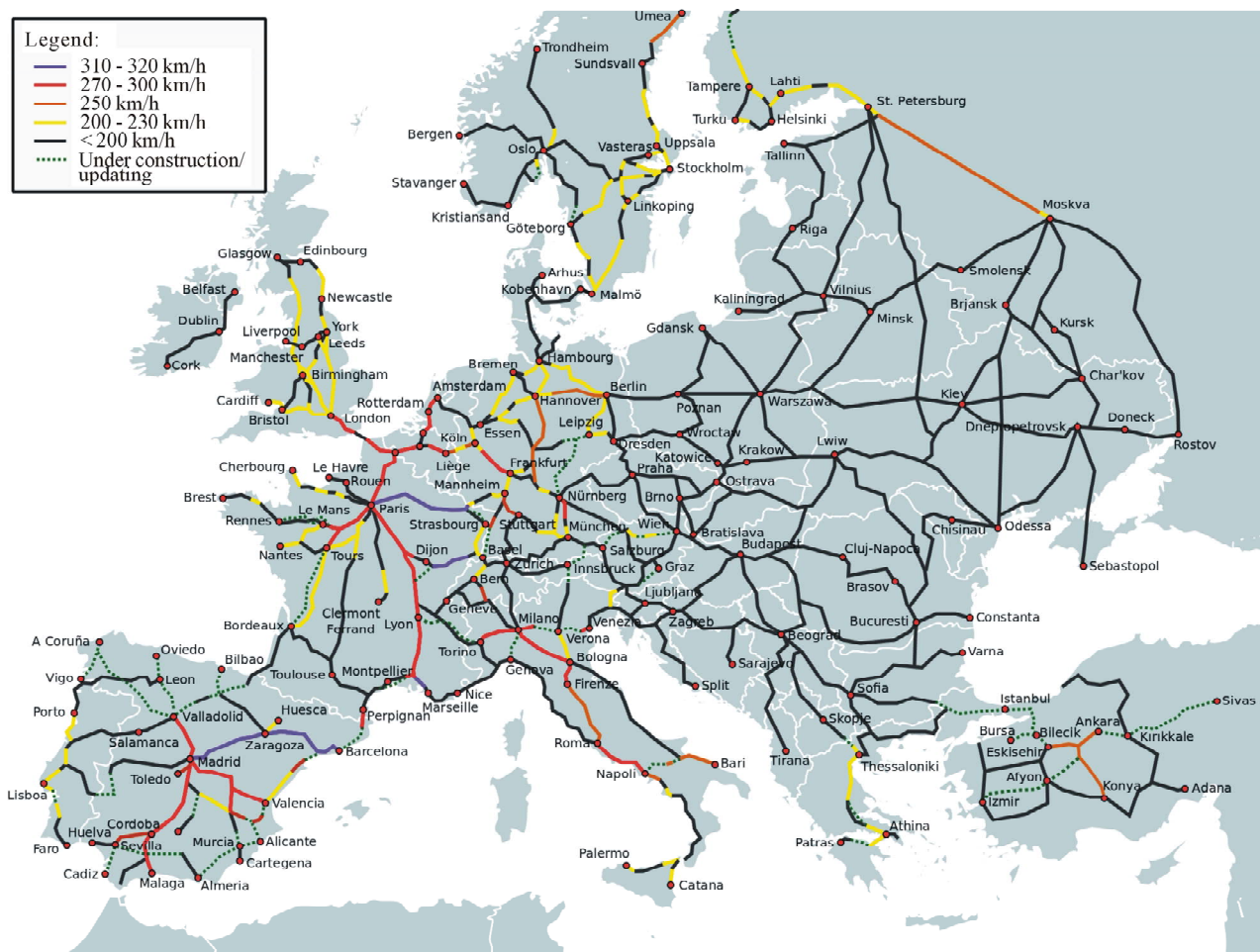


Figure 2. European network of high speed rail systems [17].

structed by a government-owned company, but was later leased to private consortium for operations [1].

France started with diesel trains in the 1960's that reached speeds of 125 mph. With increasing oil prices in the 1970's, France converted to electric powered trains built by Alstom for a line between Paris and Lyon. The electric trains cut the nearly 270 mile trip to a time of two hours, cementing the usability of the transportation method for riders. In 1981, the TGV debuted as the first HSR that would run not only on its own dedicated lines, but also on regular rail network lines. Trains on the TGV consist of a locomotive on each end with cars in between, with some lines hosting double decker train sets that can hold over 1000 passengers [6]. The HSR network of France today is over 1185 miles and counting, with typical speeds of about 186 mph [1]. French HSR tracks are stabilized using small fragments of crushed stone for a ballasted stabilization system, which is not used in Germany or Japan [7]. Spain and Korea also have high speed lines largely using French TGV technology. Over fifty percent of domestic travel in France is done by TGV [10].

Germany began developing magnetic levitation (maglev) technology for trains while also researching traditional high speed rail. Prohibitive costs stopped maglev from being a viable option for Germany, though it has been used successfully in Shanghai, China, and is

planned for Japan. Germany's high speed rail (dubbed ICE trains) system has grown slower but is at nearly 700 miles [1]. The German ICE3 systems implemented the regenerative braking systems similar to the Shinkansen line [3].

4. United States

Figure 3 shows the proposed plans for an HSR system in the United States. The United States has not seen the same boom in HSR construction and usage that other countries have. By underinvesting in high speed rail upgrades and network development, the HSR system in the United States is mostly limited to the line on the east coast. Projects, such as the one in California, have been proposed but have taken over a decade to secure the funding and actually begin the project itself. The California project proposes new HSR tracks that will be capable of speeds of 150 mph, which is unique among HSR corridors in the United States [11]. The HSR line in the United States running from Boston to Washington runs on conventional rail systems, and is the only high speed system operating in the United States. Amtrak's Northeast Corridor Mainline (Boston to D.C.) captures 62% of the travelers going between New York and Washington DC and provides connections to the major airports in the area [11]. The Northeast Corridor (NEC) system is



Figure 3. United States high speed rail vision plan [18].

Table 1. High speed rail comparison of strengths and weaknesses of various systems around the world.

Area	Strengths	Weaknesses	Economic Impacts
Asia	Drastically reduced travel times between cities [13] Highest speeds Variety of technologies used and created for changing terrains and temperatures Largest network in the world (China) Longest history of HSR systems	Huge investment from government Maglev technology cost substantially more Stock issues and losses from global projects [13]	Business can now move inland for less expensive labor Construction industries seeing a huge rise in business as growth occurs [13]
Europe	Some lines (French TGV) have proven profitable [14] Some lighter weight systems are less expensive [14] Maglev research and technology	Not an overall network yet linking the entire area [14] Diverts traffic from traditional rail networks causing them to run at a deficit [14]	Increased economic concentration in large cities [14] Less urban lines have seen (some limited) development
United States	Future rail projects can benefit from the technological advances of other countries	Limited Development Shared tracks reduce potential speeds	More than 5 million jobs are within 5 km of the Northeast Corridor system [15] California project estimated to produce 600,000 construction jobs and 450,000 permanent jobs [15]

surprisingly still one of the busiest corridors in the world, serving millions of commuters and intercity travelers [12]. However, the underinvestment and high ridership prove difficult for the tracks to handle.

Other Amtrak systems exist in the US, such as the Midwest network and the Pacific Northwest network, but they currently do not reach speeds over 100 mph [9]. United States trains tend to be heavier than their lightweight counterparts across the world, mostly due to a concern over survivability in a crash. However, various lightweight, high speed systems in the world have experienced few to no fatalities in crashes, alluding to the overall safety that can be achieved with good signaling and safety technology in place in HSR systems [11].

The main obstacle to the development of HSR in the United States is funding. It takes substantial financial resources to develop a network that is high speed, efficient, and attractive to travelers [11]. If a train system is not cutting travel times between cities sufficiently, it will not be able to attract the ridership it needs. Other issues include the balance of increasing speed with the variety of track uses. Many of the United States tracks are also used by freight systems, which has successfully worked in other countries but does impose some restrictions on speed and safety if proper technology is not used, which can also be financially encumbering. A strong HSR network in the United States will require the construction of more infrastructures to fit the needs of the technology.

5. Comparisons

While other countries have invested hundreds of billions of dollars to develop strong high speed networks, the United States has poured comparatively little into their networks. This could still result as a benefit to the United States, as future projects will enjoy the well developed technology and expansive research that others have put into their own high speed systems. Currently, many countries have seen expansive growth around their larg-

est cities, but have not seen as large of growth in others of smaller size as originally hoped. **Table 1** shows comparisons of strengths and weaknesses of HSR in various countries.

6. Conclusion

The construction of an impressive high speed rail network can be a great asset to countries and travelers alike. HSR continues to eat away at the air travel network between cities within countries, saving travelers time and reducing emissions, though thresholds exist for the likelihood of attracting passengers. In an age of increasing fuel costs, high speed rail is offering an alternative way to move for many. As rail systems become more sophisticated and continue to increase in size in Europe and Asia, other countries are set to benefit from the technological improvements and research investments that countries are pouring in to this technology. Though the United States has not poured substantial resources into creating an HSR system, the country does stand to benefit from technology and successes of other countries. However, travelers and commuters have the most to gain in an era of improved transportation technology with faster travel times, easier mobility, less road congestion, and thriving livable communities surrounding the transportation nodes.

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